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NOTES ON THE RIVER OTTER (*LUTRA CANADENSIS*)

BY EMIL E. LIERS

For the past forty years I have been interested in otters (Pl. I) and have observed them in their native haunts in Labrador and in several of the United States. In April, 1928, I started rearing and training otters for my own pleasure and edification, and later for release to zoological parks and to other institutions. Since then, those activities and lectures and demonstrations concerning the otter have become essentially my full-time occupation. In the notes that follow I have recorded some of the activities and life habits of otters as I have observed them in the wild and in pens provided for them near my home in Minnesota. The notes have been prepared at the suggestion of Dr. Emmet T. Hooper of the University of Michigan Museum of Zoology. It is hoped that they will contribute to the knowledge of the life history of the otter.

FEEDING HABITS

The food of the otter is varied. It consists of many kinds of animals that inhabit the stream in which the otter lives. It eats crayfish, frogs, turtles, larvae of aquatic insects, angleworms, and fish. One of the choicest morsels is crayfish, and where they are abundant an otter will consume a tremendous number in a year's time. The following incidences indicate some of the foods and feeding habits of the otter. In the fall months of 1949 I took some of my otters to a beaver pond in northern Minnesota where motion picture photographers recorded some of their activities. In one part of the pond the otters stood on their heads and rooted in mud and debris on the bottom. The tip of the tail of each otter showed above the surface of the shallow water. Then one otter after the other came up with large frogs, which they brought out onto the surface of the ice and ate. They also caught and ate other animals. Undoubtedly when grubbing in ponds, they get mouthfuls of mud and other debris along with the desired food. I often have watched them root in a similar manner on shallow sand bars in swift streams. In such places they often uncovered softshell or leatherback turtles. They would tear them apart and eat them. It was from the otters that I learned what became of softshell turtles in winter. On another occasion I watched otters suck on angleworms where those animals had bunched up on the

roots of trees. On some of my trips afield with my otters, when we find a pool infested with crayfish the otters feed on them ravenously. Some of the disturbed crayfish and frogs will crawl on shore where they are picked up. The otters take the crayfish in preference to the frogs. I have measured the amount of time required for crayfish to pass through the alimentary tract of otter. Otters that had previously fed only on the bland food provided in their pens passed crayfish remains in their feces about an hour after they started feeding on them.

During my early experiences in raising otter, the basic diet supplied the animals consisted principally of live fish. This diet proved to be unsatisfactory. The animals were frequently ill and not in the best of physical condition. The food that they are given now keeps them healthy. The mixture is as follows: 74 per cent ground horse meat, $\frac{1}{2}$ per cent ground raw liver, 2 per cent bone meal, 8 per cent bran, $\frac{1}{2}$ per cent grated carrots, tomatoes, or lemon or orange juice, 10 per cent raw rolled oats, and 5 per cent commercial mink meal. To this I add one teaspoonful of cod liver oil per day per otter, one ounce of brewers yeast per day per ten otters, one egg a day for each two otters. The entire concoction is mixed thoroughly with enough whole liquid milk to make a soft mash. When they are available, such tidbits as frogs and crayfish are fed as an enjoyable entree.

RANGE

Otters are great travelers. Individuals may cover 50 to 60 miles of stream course in a year. Families range about three to ten miles in a current season. If otters are trapped out in a section of a stream, such as has been done in the lower parts of the Wisconsin, St. Croix, or Chippewa rivers, in the next year or two the depleted segment of the stream will be repopulated by otter from the headwaters. In an otter-populated stream one frequently sees "pulling out" places. These are spots where otter have come out on the bank to rub themselves dry and to wallow in the grass, sand, leaves, or snow. At such places there is usually a pile of debris at which the otters have left their sign—both urine and excrement. When several otters travel together each one tries to be the last to leave its mark, if that last mark amounts only to a dribble.

In the breeding season the urge to travel seems to be particularly strong. This seems to be nature's way for distributing the animals over the countryside and in insuring mating. So far as I can see, they follow no regular pattern in dispersing. Seemingly they will go in any direction, in response to some tremendous inner urge. The following instances will illustrate what I mean. One old wild-caught Wisconsin male, Tony, mated successfully with a female, Tara, four different times in two successive days. On the third day Tara refused to accept Tony, and five other younger females refused to meet his advances. Tony left home. He did not follow watersheds, but, instead, struck out across the dry sandy pine lands. He was caught 48 hours later in a farm yard six miles from his starting point; he was very badly dehydrated and foot weary. On one of my trips into the southern United States I stopped in Indiana to exercise the otters in a ditch which crossed the highway. The ditch was full of three-square

grass and cattails. One of the female otters was in heat, but she would not accept Tony. When I returned the otters to the car, I found that Tony was missing. I followed down the ditch and finally found him; he was over three miles from the car. When I approached him he attempted to fight me, but after a few cuffs he quieted down. I carried him a short distance, then put him down and he followed me back to the car.

PLATE I

Portrait of an adult otter (New York Zoological Society Photo)

On the same trip I released a female in a creek near Albany, Georgia. The female, Toquesh, took French leave, and traveled up and down the stream for five days and nights. On the second day I had a glimpse of her and she came to my call and then again dived into the stream and disappeared. I did not see her again until four days later when she gladly came to me and seemed satisfied to go back to her crate.

On two occasions I have seen otters drive females in season away from the

rest of the group. The other otters would bite and fight the females until they had to leave. One of the females that had been driven from the group was later killed by a farmer when she stopped to play with his dogs. Another female was recovered some distance away, on an island in the Mississippi River. She followed me back home when I found her. Throughout much of the year otters are family-loving animals, but in the breeding season the family ties weaken and the individuals set out on their own. This seems to be Nature's way of scattering otters and of insuring mating. There are exceptions to this rule, however. Some males and females apparently are content to remain at home in the breeding season, and some females, after mating, remain thereafter with the male of their choice.

DENS

In the wild, otters bring forth their young in burrows, cavities among the roots of trees, and in thickets of vegetation. They use burrows made by other animals. So far as I know, an otter does not dig its own den, although it will enlarge a burrow to suit its needs. I have observed three litters in an area along about twenty miles of stream. Often the paths of the otters crossed, but I saw no evidence of fighting. One of the females had four cubs, another three, and the third had two. There were also three males in the area. The mother with two cubs did not move far from the den. Her cubs were couched in a woodchuck burrow in a hillside about 150 yards from water, and about 150 feet above high-water mark. The cubs played within about one rod of the den. They made their toilet about one yard from the den entrances. When the cubs were about eight weeks old, the mother moved them about one-half mile away to a shallow pond infested with crayfish. There they made their home in a muskrat or beaver burrow under a cottonwood tree at one end of the pond. The mother with three cubs couched them in a woodchuck burrow on the peak of the bluffs located about 500 feet above high-water mark and about one-half mile by land to water. This was a small stream that emptied into the Wisconsin River. This litter, as well as the one mentioned above, was born in the latter part of February.

In the Florida Everglades, between Clewiston and Belle Glade, another female prepared a nest in dry saw-grass marsh. The nest resembled that of a yellow-headed blackbird, but of course it was much larger. Unfortunately, that site was destined to become an emergency landing field for airplanes. As the bulldozer began working in the field, the otter was flushed and caught by workmen. The struggle and excitement caused her to abort her cubs; there were four of them. The mother died too. I know of two other nests in the Florida swamps. One was in a brush pile, the other in holes under the roots of a myrtle bay tree.

BREEDING

In Minnesota, otters breed in winter and early spring. Females in my care have been in heat in the period December to early April. The testicles of males begin descending in November. The period of heat of females lasts for 42 to 46 days, unless mating takes place. A female is not equally receptive during the entire period of heat. Days of maximum receptivity within the period are about

six days apart, between which the female is only mildly receptive or will completely reject the male. At the peak points the female will search out the male and give him every assistance in completing the mating. In my experience, few males have the ability to mate with a female at any time during her period of heat. I have had only two males in about 70 with this ability. I have had 46 males that were never able to breed a female. Therein lies one of the major difficulties that I had during the first eleven years of raising otter. In general, a male cannot be counted on as a successful breeder until it is five to seven years of age. For some reason younger males are usually unsuccessful. An otter is not sexually mature until two years old.

In the wilds several males may follow a female in heat. While on a lecture tour in Florida, I often exercised my otters in canals and ponds. On two occasions I met hunters standing at otter crossings. One hunter had just killed a male otter that he said was following a female that he had shot two hours earlier. He stated that the female was in heat. He told me that he often shot two or three otters on such a stand. At another stand a trapper told me that he had killed as many as 15 to 20 otters a year at otter crossings. Most of them were boar otter.

Successful copulation can take place either in the water or on land. In wild otters it probably occurs exclusively in the water. The male approaches the female from the rear, holds the female by the scruff of the neck with his teeth, and bends the posterior part of his body around and below the broad tail of the female. Breeding is very vigorous when contact is made. The vigorous periods are interspersed with periods of rest. In two that I timed the copulatory process lasted 16 minutes and 24 minutes, respectively. As indicated in an earlier paragraph, a pair may copulate several times in successive days. The female caterwauls when breeding.

Although otter are docile and sociable for much of the year, at breeding time males fight among themselves, particularly if there is a female in heat in the vicinity. Some males become very rough at breeding time. At least this is true of my captive otters. In an attempted mating a male will not permit interference from another male. Some males go berserk when they sense interference. They will charge anyone near, whether that individual be man or beast. Other males and females remain docile during the breeding season. They permit me to carry them to a pen or pool immediately before and after they copulate. One wild-trapped male, about 12 years old, was a perfect gentlemen of the old school. He never handled the females roughly. If I had a female in heat in my arms, this male, Blackhawk, would come over to me, take the cuff of my trousers in his mouth, and shake it, coaxing me to put the female down on the ground. A wild-caught male that had escaped performed in the same way when I found him. He came immediately to me when I called; I was carrying a female ot in my arms.

Otter will breed in zoological parks if supplied with the right kind of food and satisfactory living conditions. At the Detroit Zoological Park, for example, matings among three otters that I sold to that institution were successful. The three consisted of two females and one male. They were kept in a large pool of water

and had adequate ground for exercise. The curator saw to it that the otters were fed explicitly as I directed. In late winter of 1941 the male mated with one female and one year later she produced two cubs. The two mated again immediately and the following year she again produced a litter. Both of those litters were lost, but a third set of cubs produced the third year were saved after the male and other female had been moved from the pond.

In the wilds I have observed that males tend to keep away from areas where a female otter has couched her cubs. There will be well-marked otter crossings and trails in the vicinity, but in general most lead up only to within one-half mile of the female's den. One can see the male's tracks in the soft muddy parts of the crossings and observe his fresh sign on the pulling-out places where he has traveled to visit the female, undoubtedly holding a rendezvous with her at the opportune time to breed.

TABLE 1.—*Breeding records of captive otter*

FEMALE	AGE IN YEARS	DATE BRED	NAME OF MALE	DATE LITTER BORN	NUMBER OF YOUNG IN LITTER	GESTATION PERIOD
Tara	4	Feb. 22, '39	Tony (wild trapped, Wis.)	Jan. 1, '40	4	10 mos., 7 days
Tara	6	Jan. 1, '41	" "	Jan. 15, '42	3	12 mos., 15 days
Tara	9	Jan. 9, '44	Peewee (Tara's 2-yr.-old son)	Jan. 9, '45	2	12 mos.
Tara	12	Feb. 7, '47	Qu'Appelle	Dec. 23, '48	3	9 mos., 18 days
Jocko	8	Jan. 21, '40	Ilatomah	Jan. 11, '41	4	11 mos., 20 days
Tetawish	4	Jan. 16, '40	Ilatomah	Jan. 16, '41	4	12 mos.
Tarquol	4	Jan. 11, '43	Blackhawk	Nov. 11, '43	4	11 mos.

The period that ensues between the time that copulation has taken place and the time that the young are brought forth varies from nine months eighteen days to twelve months fifteen days. This variation has been observed in one female. Delayed implantation may be involved. In Table 1 are summarized breeding records of some of my otter.

The process of birth of the young lasts from 3 to 8 hours, depending in part on the number of young per litter. The mothers that I have watched stood on all four feet when bringing forth the cubs. One cub after the other would be dropped until the entire litter was produced. My otter produce their young in straw nests in wooden kennels. The outside temperature is sometimes 15 to 30 degrees F below zero. The female curls tightly around the cubs in such a way that they are almost completely shut off from the cold air. The cubs are toothless and blind at birth, and are quite helpless for five or six weeks. The care given the cubs is much the same as that given by female cats and dogs to their young. The mother licks them and cleans all feces from the cubs until they are about seven weeks old,

when they go to one corner of the kennel for their toilet. Cubs (Pl. II) thrive much better on otter's milk than on cow's milk. When I bottle-feed orphans with cow's milk they do not develop as fast as those fed by their own mother. The eyes open when the young are about thirty-five days old. When the cubs are five to six weeks old they begin to play with one another and with their mother, and when ten to twelve weeks old the mother first permits them to exercise and play outside of the nest.

PLATE II

Otter cubs (Gatterdam Photo)

Cubs must be coaxed into the water. Sometimes, the mother has to drag a cub by the loose skin of the neck in order to get it into the water. On their first attempts at swimming they seem to be head-heavy; the head continually tips down underneath the surface of the water, but after much struggling and sputtering, they learn to swim. The mother catches crayfish, frogs, and top-minnows, and calls to the young to come and get the food. Her call in such instances is a long drawn-out sound, sounding to me like un-huh, un-huh. When the first cub reaches her to get the food, either after swimming directly to her or running

about on shore in order to reach her, she releases the food and the cub is on its own. Generally the quarry will escape into the water and the cub flounders about trying to find it. The mother obtains more food, gives the same long drawn-out call, and the cubs go through the same process. It is in this way that they acquire skill in catching and holding food. The mother generally leads the way, calling the cubs to follow. If they get too venturesome and try to rush ahead, the mother nips them on the nose. When she does so, the punished cub drops down and lies very quiet. When punishment is severe, the cub remains in a supine position and does not run forward until the mother returns to it and caresses it as if telling the cub that everything is all right, but just to behave.

PLATE III

Otters sliding down a snow-covered bank (Gatterdam Photo)

FAMILY LIFE

The mother usually will not allow the father or anyone else to come near the cubs until they are at least six months old. Males as well as females are usually kind to the young. When I acquire young orphan otters, males will sometimes adopt the cubs and catch food for them. In my experience, it is the young female which is more often unkind to these strange cubs. However, by far the majority of the older otters are kind and gentle with cubs. When permitted, the male will assist in the care of them. He is patient even in their most vigorous play, when they tweak his whiskers and in general make a nuisance of themselves.

Otters may become particularly attached to some person or thing. One old wild-trapped male, Tony, had lived with a trapper and his children for nine years before I bought him. Thereafter he always liked and never forgot children. When he was sixteen years old I saw him go up to a child, caress the child's cheek, and murmur sweet nothings in otter talk.

Over most of the year otters are social, gentle, and playful. They also are quite loyal to each other. If another otter is in trouble, or their master or even a dog that they are attached to is in difficulty, all otter in the vicinity will pitch in to fight off the danger. On one occasion while I was walking with some of my otters through a field, a farmer's dog ran out to attack my Airedale that was also along with us. The otters immediately jumped into the fight and drove the stranger howling from the scene. On another occasion a strange dog attacked me; it bit my hand and tore one finger to the bone. The otters that were loose in my yard came charging to my assistance and drove the dog off of the premises.

Otters love to play in the water and to romp and slide across the countryside. They are all excellent swimmers, but some are faster than others. When attempting to cover distance, and not merely playing in the water, they undulate as they swim, spending part of the time on top and part of the time underneath the water. In such instances I have to walk as fast as I can in order to keep pace with them. On land an otter can run as fast as a man. When traveling overland and on snow or ice they combine running with sliding. They run a ways, then fold their front feet under their bodies and slide (Pl. III); then they repeat the running and sliding process. They travel very fast in this way. They enjoy sliding to the full. Finding a hill that is clear of debris, they will coast to the bottom, do an immelmann turn there, and run immediately to the top to repeat the performance. Even though the ground may be slightly rough, so that they will get repeated bumps on their stomachs, they will coast again and again. On a particularly steep and slippery slide the rare otter that may not like the excessive speed will thrust his fore paws forward to slow the pace or even to break itself to a stop. But it is usually not long until that timid one has become accustomed to the speed and he joins with the others in the sliding game with reckless abandon. In the summer, otter will substitute mud or grassy banks for the snowy hills. But snow is always tops for otter slides and it is on those slides that they let their good nature show by their playing, tussling, and wrestling for all that they are worth. It is a picture of perfect relaxation. Otter in the wilds travel mostly at night. But those at my home are active in the day time and sleep at night. They sleep about twelve hours out of each twenty-four, including about two hours in the middle of the day.

Otters make several sounds. One is a shrill chirp which sounds like the chirping of a baby chick. They make these chirping sounds when they are coaxing me to permit them to get out of their cages. When some people have heard these sounds, they have asked me if the animals had the hiccups. Another sound that they make is a soft chuckle, which to me expresses a variety of their emotional states. Another sound is a scream. Vented in anger or fight, the scream resembles that of a mink, but is considerably louder. If fright or anger is the cause of the scream, the otters will usually give forth musk from their scent glands. The only times that I have had otter exude their scent is when they are frightened. Finally, females caterwaul when in the process of copulation. The chirp and chuckle are the sounds mostly used.

Homer (Winona County), Minnesota. Received April 5, 1950.

MEASUREMENTS OF SEA OTTERS FROM WESTERN ALASKA

By Victor B. Scheffer

The hunting of the sea otter, *Enhydra lutris* (L.) in North American waters has been forbidden by international treaty since 1911 and, as a result, few specimens have found their way into museum collections. In order to reach a better understanding of the characteristics of the sea otter we assembled, between 1947 and 1949, a collection of skins and skulls from the coast of Alaska, most of them salvaged from animals dying of natural causes. The skulls (and of several, the skins) of 120 individuals are included. Although the collection is oddly assorted and not as representative as one might wish, it furnishes certain useful information on size and variability.

We are deeply grateful to Elmer C. Hanson, of the United States Department of National Defense, who was stationed on Amchitka Island for several years and who gathered most of our study material. We also appreciate the help of colleagues in the Fish and Wildlife Service: Robert D. Jones, Karl W. Kenyon, and Ford Wilke.

Body measurements; adult male.—Specimen BDM 128 weighed 76 pounds and measured, in the flesh, as follows (millimeters): length, 1478 (58 inches); tail (a poor measurement), 360; hind foot, 220; stretched width of hind foot, 200; tail width at base, 67; tail length from anus, 292; forearm, elbow to tip of claw, 201; hind leg, knee to tip of longest (fifth) claw, 415; girth at armpits, 680; maximum girth (belly) over fur, 950; preputial opening to anus, 222; maximum depth (thickness) of body, through chest, 165; longest vibrissa, 74; ear from notch, 32; ear from base, 33.

The skull "size-index" (that is, condylobasal length × mastoid width/100) of the foregoing specimen is 149. In our entire collection of skulls, only one other is larger, an individual (sex unrecorded, but certainly a male) with size-index 150. Thus, we are satisfied that the male sea otter seldom exceeds 58 inches in lenth and about 80 pounds in weight.

Barabash-Nikiforov (1935: 255) says of the Commander Islands sea otters, "the maximum size recorded is a length of 1,460 mm. [57.5 inches], with a weight of 37,000 grams [81.6 pounds]." Although he does not specifically state so, the animal referred to is certainly a male.

Hanson was able to obtain the lengths of six adult males among the stranded carcasses and skeletons which he found on Amchitka Island. Values were, in decreasing order (inches and millimeters): $56\frac{3}{4}$ [1441], 55 [1397], $54\frac{3}{4}$ [1390], 54 [1371], and 50 [1270]. The skulls are fully adult. For one of the aforementioned individuals (length $54\frac{3}{4}$ inches), the sex was not recorded, although the size of the skull (condylobasal length, 143; diameter upper canine, 11.7) is definitely that of a male.

Adult female.—There seem to be no published records of the size of a fully adult female sea otter. Thus, it is of interest to note the measurements obtained by Hanson and Jones of two individuals, as follows: Specimen ECH 87: length, $50\frac{3}{4}$ inches [1289 mm.]; tail, $10\frac{3}{4}$ inches [273 mm.]; hind foot, $8\frac{3}{4}$ inches [222 mm.];

weight, 43¼ pounds; "evidence of advanced age . . . . a large animal." This female was picked up sick and was held in captivity for a day before she died, apparently of an embolus. Specimen ECH 34: length, 49 inches [1244 mm.]; tail, 11 inches [279 mm.]; hind foot, 9 inches [228 mm.]. The skull of this individual is fully adult and has a size-index of 121.

Newborn young.—The measurements of three very small sea otters, two females and one male, are, respectively: length, 551, 560, 635 mm.; tail, 123, 134, 160; hind foot, 111, 121,—; ear from notch, 13, 16, —; ear from base, 15, 17, —; weight, 3.6, 4.3, 5.4 pounds. Kenyon found a fresh umbilical fragment attached to specimen BDM 377. It appeared to be frayed, as though bitten. Barabash-Nikiforov (1935: 256) gives the average size of the newborn sea otter as: length, 440 mm. [17.3 inches]; weight, 2000 grams [4.4 pounds].

The statement is often encountered in mammalian literature (e.g., Scammon, 1874: 168) that the young otter is apt to be born at any time of the year. While we can not prove or disprove this statement, we should like to point out that our very young specimens, three in number, were all collected in late spring, that is, 6 April (3.6 pounds), 6 April (4.4 pounds), and 16 May (5.4 pounds). Furthermore, a small skull in the National Museum (Biological Surveys Collection, no. 93314, male) is apparently that of an animal born in April or May. It was collected at Point Granville, Washington, on 28 May 1898. Its condylobasal length is 84, as compared with lengths of 72 and 76 for the two Amchitka specimens, BDM nos. 377 and 378.

Skull measurements.—Altogether, 118 complete or fragmentary skulls are available for study. These include: young males, 12; adult males, 9; young females, 4; adult females, 2; young, sex unknown, 56; adult, sex unknown, 35; total young, 72; total adults, 46. Measurements of selected, large, adult, male and female skulls are shown in Table 1.

Sex differences in the skull.—At the start of the present study, we searched for a means of separating the males from the females in a lot of 35 unknown-sex, adult skulls from Amchitka Island. Unfortunately, we have been unable to find a positive clue to the sex, although we have scrutinized all of the variates listed in Table 2 and several others. While, in females, the skull is smaller and the canine tooth is slenderer than in males of comparable age, the differences are not sufficiently pronounced to serve as a basis for separating the sexes of *all* skulls. The width of the canine tooth seems to be the best clue found thus far. (Since the males probably do more fighting than the females, it is not surprising to find that the males have the stronger canines.)

The development of a typical upper canine is described in the following series of notes. In a young but not newborn animal (ECH no. 103, unknown sex, body length 723 mm.) the tip of the canine is erupting and is level with the rim of the alveolus. The tooth is conical, 9.2 mm. in diameter at the open root and 19.6 mm. in length. The narrowest fully adult canine in the collection (ECH no. 13-48, unknown sex, probably female) is 9.1 mm. wide. The shortest unworn adult canine (ECH no. 110, unknown sex) is 37.8 mm. in length. In the male, the tooth reaches a maximum width of 12.1 mm. (ECH no. 24) and a maximum

length of 44.3 mm. (ECH no. 9). In the female, the tooth probably reaches a maximum size of 10 x 40 mm., although the evidence on this is meager. In very old animals, the crown of the tooth becomes so shortened by attrition that a valid length measurement can not be taken. The root of the tooth closes completely when the otter reaches adulthood, that is, when the basioccipital-basisphenoid suture closes.

The values for width of canine in 32 adult skulls, most of them of unknown sex, are arrayed in Table 2. These data indicate, we believe, that an adult canine less than 10 mm. in width is probably that of a female, and an adult canine greater than 10 mm. is that of a male. (Even in our young male skulls, a total of ten, the width does not fall below 10 mm.) If, however, we had a larger series of adult female skulls we might find that, in some, the canines would ex-

TABLE 1.—*Cranial measurements of large adult sea otters from western Alaska*[1]

MEASUREMENT	ECH NO. 93, PROBABLE MALE	BDM 128, KNOWN MALE	USNM 36266, KNOWN FEMALE	ECH NO. 13-48, PROBABLE FEMALE	ECH NO. 34, KNOWN FEMALE
Size-index[2]	150	149	128	128	122
Condylobasal length	146	141	131	133	131
Basilar length of Hensel	125	124	—	116	—
Palatilar length	64	62	56	58	57
Zygomatic width	111	109	103	101	97
Mastoid width	103	106	98	96	93
Width across postorbital processes	48	48	42	45	41
Interorbital width	45	44	38	41	39
Width of postorbital constriction	30	32	22	28	28
Width of right upper canine	12	—	—	9.1	9.2
Height of lamboidal crest	8	8	—	7	5
Height of sagittal crest	6	6	—	5	4

[1] In millimeters; methods of measurement, in part, as described by Grinnell, Dixon, and Linsdale, 1937, pp. 43–44.

[2] Condylobasal length × mastoid width/100.

ceed 10 mm. in width and would in this respect resemble the canines of small males.

Dentition of newborn.—The dentition of a newborn sea otter was clearly demonstrated in the fresh carcass and, subsequently, the cleaned skull of specimen BDM 377. The excellent preservation of the skull is a tribute to the technique of Karl W. Kenyon, who cleaned it. In the upper jaw, three deciduous incisors have erupted anterior to the three alveoli of the permanent incisors. DI^1 and DI^2 are weak and spindly, 1.1 and 1.6 mm. in exposed length. DI^3 is well formed, 4.6 mm. in exposed length. All of the deciduous incisors have broken through the gum in the fresh specimen. Sunken in their respective alveoli, the tips of the permanent incisors may be seen. The deciduous canine is 5.8 mm. in exposed length and shows in the fresh specimen. A single deciduous premolar (DPm^1) shows in the fresh specimen and in the cleaned skull. It is 2.7 mm. in exposed length. DPm^2 has very nearly erupted. Miss Fisher (1941: 429) concluded from

a study of young skulls, most of them presented to her in poor condition, that DPm^2 appears in the first stage of the dentition of the sea otter. From the evidence of our specimens, BDM 377 and 378, only one deciduous upper premolar should be credited to the newborn young.

In the lower jaw there are three deciduous incisors. DI_1 and DI_3 are 1.5 and 1.6 mm. in exposed length, respectively. Both have emerged from the gum in the fresh specimen. The middle tooth, DI_2 is small and slender, about 1 mm. in exposed length, and is not visible in the mouth of the fresh specimen. The deciduous canine is robust, 6.0 mm. in exposed length. It appears in the fresh specimen. Deciduous premolars 1 and 2 have each erupted to a height of about 2 mm. above the jaw bone. DPm_2, however, appears only as a swelling, not as a tooth, in the mouth of the fresh specimen. It is perhaps a matter of opinion

TABLE 2.—*Greatest width of right upper canine in adult sea otter skulls from western Alaska*

MILLIMETERS, CLASS INTERVAL 3	FREQUENCY			
	Males	Females	Sex?	Total
9.1– 9.3		1	3	4
9.4– 9.6		1[1]	3	4
9.7– 9.9				0
10.0–10.2			3	3
10.3–10.5	2		6	8
10.6–10.8				0
10.9–11.1	2		2	4
11.2–11.4	3		1	4
11.5–11.7			2	2
11.8–12.0	1		1	2
12.1–12.3			1	1
Total	8	2	22	32
Minimum	10.5	9.2	9.1	9.1
Maximum	11.8	9.5	12.1	12.1

[1] From Oregon, USNM 3206.

whether one should consider it part of the visible dentition of the newborn young.

In conclusion, with respect to the teeth that have erupted through the gums, the newborn sea otter has five teeth, all deciduous, in each half of each jaw, or a total of 20.

The baculum.—Eighteen specimens in our collection from western Alaska measure in length as follows (millimeters): young, 58, 72, 79, 82, 89, 90, 92, 98, 100; adult, 146, 153, 157, 157, 158, 159, 161, 164, 164.

Sea otter specimens examined.—Lot 1: Two entire animals, adult male (BDM 128) and subadult female (BDM 129) collected by Victor B. Scheffer, William H. Sholes, Jr., and Robert Zanes Brown, near Simeonof Island, Shumagin Islands, 2 June 1947.

Lot 2: Six skulls picked up by Scheffer and party on Amchitka Island, 12 November 1947.

Lot 3: Nineteen skulls and one skin-with-skull (ECH 2–48 to 31–48, with gaps), collected by Elmer C. Hanson on Amchitka Island, 12 May to 4 December 1948.

Lot 4: Eighty-six skulls, two skins-with-skull, and two skins only, collected by Elmer C. Hanson and Robert D. Jones on Amchitka Island. ECH nos. 1–46 (with gaps) were collected by Hanson alone, 13 February to 7 April 1949; nos. 47–106 (with gaps) by Hanson and Jones, 6 April to 1 May 1949; and nos. 107–127 (with gaps) by Hanson alone, 8 May to 15 July 1949.

Lot 5: Two newborn females, entire, found on Amchitka Island, 6 April 1949, by Hanson and Jones. The collectors froze the specimens and forwarded them to Seattle, where Kenyon measured and skinned them on 4 November 1949 and accessioned them as BDM nos. 377 and 378.

For purposes of comparison, we examined certain sea otter skulls from the northeastern and northwestern Pacific Ocean and Bering Sea, in the U. S. National Museum (17 specimens) and the U. S. Biological Surveys Collection (6 specimens).

Summary.—In a study of 120 sea otter specimens, most of them skulls only, from western Alaska, we find that the adult male attains a length of 1478 mm. and a weight of 76 pounds; the adult female, 1289 mm. and 43½ pounds. The smallest newborn young has a length of 551 mm. and a weight of 3.6 pounds. The evidence of five specimens (two from outside sources) is that the young are born in April and May, rather than the year around. The maximum "size-index" (CBL × MW/100) of male skulls is 150; of females, 128. The sex differences in skulls are not pronounced, although the female skull tends to be smaller. The upper canine of the adult male is over 10 mm. in width, while the corresponding measurement of the adult female is probably, but not certainly, less than 10. In each half of each jaw of the newborn young there are five deciduous teeth, as follows: 3 incisors, 1 canine, and 1 premolar. The baculum attains a maximum length of 164 mm.

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SPRING, SUMMER, AND FALL CENSUSES OF THE PINNIPEDS ON SAN NICOLAS ISLAND, CALIFORNIA

By George A. Bartholomew, Jr.

Between May 11, 1949, and April 24, 1950, through the kindness and co-operation of the United States Navy, I was able to make six visits to San Nicolas, the outermost of the islands off the coast of southern California. One of the purposes of these visits was to take censuses of the pinnipeds, and the results of these counts are presented here.

All of the species of seals and sea lions known to come ashore regularly in California occur on San Nicolas. The gregarious nature of the seals and sea lions and the marked localization of their hauling grounds made it possible to make a careful on-the-spot count of all the animals hauled out on the island.

The location of the hauling grounds was a relatively simple matter. The major ones were known to the naval personnel on the island. On two different occasions it was possible to examine the entire coast of the island from the air. As a final check the whole coast line was visited either by jeep or on foot.

The censuses were taken by observation with naked eye, binoculars, or telescope. All possible areas within each hauling ground were examined and this occasionally required crawling directly through the rookeries. To avoid frightening the animals into the water, however, most of the counts were made from distances of 100 to 400 feet. The number of individuals reported represents a minimal number for the island because it was not possible to determine the number of animals at sea while the censuses were being taken.

The results of the six censuses are summarized in Table 1 and the situation with regard to each of the species found is discussed briefly below. Because of bad weather and limitations on time, on one of the trips it was not possible to take a complete census of the *Zalophus*, and on three of the trips it was not possible to take a complete census of the *Phoca*.

I am indebted to the officers and men of the Naval Air Missile Test Center, Point Mugu, California, for their co-operation and assistance, and to William G. Reeder, William R. Dawson, Herbert Caswell, and Yost Amrein for help in taking the censuses.

CALIFORNIA SEA LION, *ZALOPHUS CALIFORNIANUS*

By far the most abundant, conspicuous, and vociferous of the pinnipeds on San Nicolas are the California sea lions. Individuals of this species were commonly seen swimming in the water all about the island, but during the May and June censuses they were found on shore in only three areas and during the July, December, and April censuses they were concentrated in but two of these areas, each completely different in character from the other.

One of these sites (area 4) an extensive sandy beach 3.2 nautical miles south of the western tip of the island (see Fig. 1) was completely unprotected and so was subject to the full force of the waves. Sea lions could be seen at any time

of day playing in the extremely heavy surf and at all times large numbers were hauled out on the sand. Despite the fact that the total sea lion population of the island increased during the spring and early summer, during this period the number of animals on area 4 fell off markedly. The number of sea lions using this beach apparently remained low during the fall, but by April 22, 1950, the

TABLE 1.—*Numbers of pinnipeds on San Nicolas Island, California. Unless qualified, numbers include animals of both sexes and all ages*

SPECIES	MAY 11–13, 1949	JUNE 18–20, 1949	JULY 9–11, 1949	JULY 22–23, 1949	DEC. 16–17, 1949	APRIL 22–24, 1950
Zalophus californianus	1990 and 6 new-born	2020 and 433 new-born	2658 and 895 new-born	census incomplete	2142	4058
Eumetopias jubata	0	1	2	1	2	2
Arctocephalus townsendi	1	1	1	1	0	0
Phoca vitulina	census incomplete	141	177	census incomplete	census incomplete	125
Mirounga angustirostris	143	69	24	17	24	168

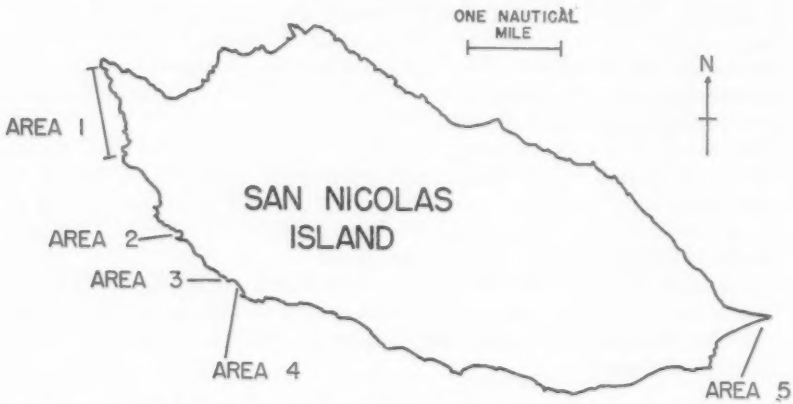

FIG. 1.—Map of San Nicolas Island, California, showing the location of the principal hauling grounds of the pinnipeds.

number had increased to almost 1000 (Table 2). At all seasons at least 80 per cent of the animals in area 4 were males. No young were born on this beach.

As shown in Table 2, during the May census more than 200 sea lions shared the hauling ground at area 3 (Fig. 1 and Pl. I) with the elephant seals. Although at least two young were born here during June, by July 9 the sea lions had left, presumably having moved to area 1.

The main sea lion rookery, area 1, extended continuously for almost 1.5 nautical miles along the coast from the extreme west end of the island (see Fig. 1).

PLATE I

UPPER: Female California sea lions with newborn young on the rocky beach of one of the coves in area 1. The nesting birds are Brandt cormorants. Photograph taken June 19, 1949.

LOWER: Hauling ground at area 3 on May 13, 1949, showing part of the mixed herd of elephant seals and California sea lions.

The coast on which the rookery is located is extensively dissected and cut into a series of sheltered channels, pools, and deep coves, some of which end in sea caves. The entire strip of shore is rocky and the beaches are small and of limited extent. The rookery is easily accessible from the landward side. The distribution of sea lions in the rookery is not uniform, there being concentrations in the coves and in certain of the flat rocky areas.

During the spring and early summer of 1949 the population of the rookery at area 1 increased steadily (Table 2) and by July 9 there were 2494 animals one year old or older and 895 newly born young. This makes the San Nicolas rookery by far the largest breeding colony of the California sea lion that has so far been found in California. The biggest breeding rookery that has previously been reported is that on Santa Barbara Island from which Bonnot and Ripley (1948) recorded 1000 animals (not including young) in 1947.

The 2658 one-year-old or older *Zalophus* found on San Nicolas during the summer of 1949 made the California sea lion population of this island alone larger than the populations found in the entire state by the California Division

TABLE 2.—*The population and distribution of Zalophus californianus on San Nicolas Island, California. The location of areas 1, 3, and 4 are shown on Fig. 1. Unless qualified, numbers include animals of both sexes and all ages*

	MAY 11–13, 1949	JUNE 18–20, 1949	JULY 9–11, 1949	JULY 22–23, 1949	DEC. 16–17, 1949	APRIL 22–24 1950
Area 1	1476, 4 new-born	1532, 433 new-born	2494, 895 new-born	census incomplete	2059	3102
Area 3	203, 2 new-born	163	0	3	0	0
Area 4	311	325	164	52	83	956
Total	1990, 6 new-born	2020, 433 new-born	2658, 895 new-born	census incomplete	2142	4058

of Fish and Game during their summer censuses of 1927, 1928, 1930, 1936, and 1938, and only 15 per cent smaller than the 3050 animals reported (Bonnot and Ripley, *op. cit.*) as the state population during the summer of 1947.

San Nicolas has been included in the state-wide sea lion censuses only twice. In 1946 (Bureau of Marine Fisheries, 1947), 284 *Zalophus* were found there, and in 1947 (Bonnot and Ripley, *op. cit.*), 660 were counted there. The large number of sea lions found on San Nicolas during the summer of 1949 may be related to an increase in the population of this species in California waters or may simply be due to a great influx of the animals to San Nicolas. During the war years the side of San Nicolas now occupied by the sea lions was a gunnery range for military aircraft and naval vessels and it may be that many of the sea lions abandoned the island for this reason and are only now returning to it in large numbers. In any event the large number of sea lions found on San Nicolas during the summer of 1949 strongly suggests that the total number of *Zalophus* present in California waters at this time had increased considerably beyond the 3050 counted in 1947.

Under the extremely congested conditions found on the hauling grounds on San Nicolas, it was impossible to differentiate accurately between young of the year and older animals during the December, 1949, and April, 1950, censuses. As shown in Table 1, by mid-December the number of California sea lions on San Nicolas Island had declined from the summer level, but by the latter part of the following April the population had increased to a point even beyond the level of the previous summer.

Very little is known about the seasonal movements of sea lions on the Pacific Coast, but it appears (Fry, 1939, and Bureau of Marine Fisheries, *op. cit.*) that the winter population of *Zalophus* in California exceeds the summer population. It is impossible to say at the present time whether or not the population of 4058 *Zalophus* on San Nicolas on April 22 and 23, 1950, represented in part transient winter animals or consisted only of animals which were going to breed on the island. The fact remains, however, that the population of *Zalophus* on San Nicolas during the last part of April, 1950, exceeded that known to have occurred during the summer in the entire state of California at any time since the Division of Fish and Game began its pinniped censuses in 1927.

STELLER SEA LION, *EUMETOPIAS JUBATA*

According to Rowley (1929) the southernmost breeding locality of the Steller sea lion is on Santa Rosa Island, which is approximately 42 nautical miles north of San Nicolas. The only *Eumetopias* seen on San Nicolas were isolated individuals (see Table 1) either females or young males, which were hauled out in the *Zalophus* rookery in area 1. No indication of reproductive activity was apparent.

GUADALUPE FUR SEAL, *ARCTOCEPHALUS TOWNSENDI*

On the first four of the six visits to San Nicolas an individual male fur seal of the genus *Arctocephalus* was found in area 1 among the California sea lions. Presumably this animal is referable to the species *townsendi*. The details of these encounters have previously been described (Bartholomew, 1950*b*).

HARBOR SEAL, *PHOCA VITULINA*

In its choice of San Nicolas as a hauling ground the harbor seal belies its name, for not only is San Nicolas the outermost of the continental islands off the west coast of the United States, but it has no harbors or bays.

Harbor seals were often seen as isolated individuals or in groups of five to ten in the sea lion rookery in area 1, and at any hour of the day individuals could be seen swimming just outside the surf off all parts of the island. There were, however, two beaches where groups varying in size from 50 to 132 were regularly found hauled out. One of these sites, area 2, is a smooth sandy beach 2.1 nautical miles southwest of the extreme west end of the island. The other, area 5, is at the end of the sand spit which extends about 1200 yards out from the eastern tip of the island. Both of these hauling grounds are subject to heavy surf and are completely lacking in shelter and protection.

Although the evidence is circumstantial, at least some of the harbor seals ap-

pear to be resident breeders on San Nicolas, for on each trip a number of young of the year were seen.

NORTHERN ELEPHANT SEAL, *MIROUNGA ANGUSTIROSTRIS*

The presence of elephant seals off the California coast has been known for a number of years. Loye Miller (personal communication) found 13 immature animals on San Miguel during the summer of 1938. During the California Fish and Game sea lion census of the same year, Bonnot, Clark and Hatton (1938) reported finding four yearling elephant seals in the Channel Islands, and Fitch and Wilson (1949) reported that a group of 21 had been seen on one of the Channel Islands in 1946.

The 143 animals seen on San Nicolas on May 11–13, 1949, and the 168 animals seen there on April 22–23, 1950, represent by far the largest groups of elephant seals known to have occurred in California waters since the middle of the nineteenth century. The presence of these animals is an expression of the steady increase in number that has been shown by this species during the past 40 years and is further evidence that the northern elephant seal is beginning to reoccupy its original range.

As shown in Table 1 there was a conspicuous seasonal change in the number of elephant seals hauled out on San Nicolas with the maximum number being present in spring and the minimum in summer and fall. The decrease in numbers during the summer and fall was not accompanied by any perceptible change in the composition of the population which at all times during the summer and fall included animals of both sexes and all sizes. In April, 1950, however, the larger males were conspicuously reduced in number, there being only six males as long as eleven or twelve feet and none of these had probosces more than one-third developed. It is noteworthy that although large young males were fairly common in all of the censuses except the last one, during all of the observations on San Nicolas, only two old battle-scarred bulls were seen.

A decrease in the population of elephant seals during the summer and fall, similar to that on San Nicolas, apparently occurred at the same time in the Coronados Islands, which lie off the extreme northern coast of Baja California, where in the last week of April, 1949, a herd of 73 animals was observed on South Island (Bartholomew, 1950). On August 14–16, 1949, South Island was carefully searched by Robert G. Lindberg and only five elephant seals could be found, and on November 27, 1949, South Island was examined from sea by both Carl L. Hubbs and me and fewer than five animals were seen.

Elephant seals were found on only two parts of San Nicolas. During each of the censuses 80 per cent or more of the population was on a sheltered beach, area 3, opening off a tiny cove on the southwest side of the island (Pl. I) and the remaining animals were found as isolated individuals or in small groups among the sea lions in area 1.

To date there is no conclusive evidence as to whether or not the elephant seal breeds on San Nicolas.

SUMMARY

Between May 11, 1949, and April 24, 1950, six censuses of the pinnipeds of San Nicolas Island, California, were made. The most abundant pinniped on the island is the California sea lion. At least 895 young of this species were born on San Nicolas during the summer of 1949, at which time the population of this species on the island included approximately 2600 animals one year old or older. The population declined during the fall and in mid-December it had fallen to approximately 2100 animals (including young born the preceding summer). By the latter part of April, 1950, however, the population had built up to slightly over 4000 animals of all ages.

The Steller sea lion was represented by only a few stragglers. In four of the six censuses a single male Guadalupe fur seal was seen. Harbor seals reside and apparently breed on San Nicolas in considerable numbers despite the island's exposed and isolated position. The northern elephant seal is a conspicuous member of the island's fauna. The 168 elephant seals hauled out on the island in April, 1950, represent by far the largest single herd of this species that has been found in California since the middle of the nineteenth century.

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THE STATUS OF THE MANATEE IN THE EVERGLADES NATIONAL PARK, WITH NOTES ON ITS NATURAL HISTORY

By Joseph Curtis Moore

As long as fifty-five years ago biologists had begun to write with concern (Bangs, 1895: 786) for the survival of the Florida manatee, *Trichechus manatus latirostris*. Impressed by the number killed in the 1940 freeze, Cahn (1940: 222) considered the survival of the species to be seriously threatened. Two years later Glover Allen (1942: 544) included the Florida manatee in his EXTINCT AND VANISHING MAMMALS OF THE WESTERN HEMISPHERE, and Gordon Gunter (1942: 89) wrote: "For years it has been a matter of common knowledge with conservationists and mammalogists that manatees are very uncommon in the United States." Many have shared their concern, and many have looked forward to the recent establishment of the Everglades National Park with the hope that it should provide for the indefinite survival of this interesting creature. It seems fitting, therefore, that this early opportunity be taken to report on the apparent status of the manatee in this park, and to record such information on its natural history as is at hand. Observations were begun in May, 1949, and continued through April, 1950.

Much credit is due park superintendent Daniel B. Beard for setting up a position in the Park which provided the opportunity for this study, and for the interest and enthusiasm with which he encouraged its progress. Park warden Marcus B. Parker, a keen and intelligent observer with long years of experience in the area as a warden for the National Audubon Society before the Park was established, and park ranger Ralph D. Maxwell, a well-trained wildlife management graduate, recorded and contributed many field observations. Others who provided sight records are Paul Barnes, David Bogart, J. B. Earle, John Rohn, Earl Semingsen, and Erwin Winte of the Ranger staff, Lamar Johnson of West Palm Beach, Burton Hunt of the University of Miami, Charles M. Brookfield and Jay A. Weber of Miami, charter boatman Lewis C. Watson, and local fishermen H. B. Brewer, Rollin Davis, Joseph Douthitt, C. E. Saunders, Art Eiffler, and Fred Woodard. W. M. Buswell of the University of Miami identified a food plant. The MIAMI HERALD newspaper gave courteous access to its clipping files. Lester Leigh in a letter of May 7, 1950, provided measurements of a six-foot male Florida manatee in his care in the South Florida Museum at Bradenton. Special acknowledgment is made to Claude Lowe of Tavernier who generously contributed his carefully recorded notes on the birth of a manatee, and measurements of the parous female.

The Everglades National Park at this writing (April, 1950) includes some 1,228,500 acres on and about the southernmost projection of the mainland of Florida and of the United States, between latitudes 24° 50′ and 25° 45′. It may be divided into three very distinct parts, grossly equal in area: the sawgrass glades, the mangrove swamps, and Florida Bay. The glades concern us only indirectly here. This expanse of open sawgrass marsh, frequently dotted with tree

islands, extends southward into the Park area from the lip of Lake Okeechobee. There is flow of water southward through this marsh, particularly in the area of sloughs which forms its core. Water falling on 15,570 square miles of south Florida once eked its way among the sedges and grasses of this marsh southward to the latitude of the present Park boundary, 25° 45′, and thence southwestward toward the Gulf of Mexico. Nearing the Gulf, the concentrating water scoured out channels in the bed rock to form myriad tributaries and interconnecting waterways and rivers which carry this fresh water down to Whitewater Bay and to the Gulf. The land area in which this labyrinth of waterways was cut is occupied by mangrove swamp. It constitutes the second part of the Park. The twelve named rivers with their interconnections and tributaries, and many shallow bays of this part, constitute what appears to be the greatest concentration of manatee habitat in the United States. The third part of the Park is triangular Florida Bay, an exceedingly shallow but very large bay lying south of the mainland of Florida, separating it from the arc of outer keys. In this are many square miles of marine vegetation of several kinds alleged to be food of the manatee.

Numbers and distribution.—As may be seen from the distribution chart (Fig. 1), the mangrove area which includes Whitewater Bay and its rivers, the Shark River, and the Broad and Rogers rivers, is that in which manatees have survived their persecution best. This area is now under the protection of the ranger staff of the Everglades National Park, and the manatees here may be expected to increase. In Florida Bay which only became a part of the Park in February, 1950, the manatee appears to have been virtually exterminated. According to Rollin Davis, a septogenerian who farmed with his father on Deer Key in Florida Bay in 1894, manatees at one time occurred about Mud Creek, Trout Creek, and especially Manatee Creek. Long Sound and Manatee Bay were connected by Manatee Creek before the creek was blocked by the fill which now supports the overseas highway to the keys. Both Davis and Douthitt told me that there are still manatee in Manatee Bay, and the Burgoses, who operate a small fishing camp on Barnes Sound 2.7 miles northwest of Jewfish Creek, told me of seeing several just off their camp in the second week of January, 1950. Woodard saw one several times in 1948 lingering about Oyster Key in the West end of Florida Bay, and Brewer untangled a large one from a fish net which he had set just off the mouth of Slagles Ditch in the same vicinity in 1938. Brookfield saw one at Manatee Key in January, 1946. Many local fishermen have never seen one in western Florida Bay. Cowpens Key was so named because manatees were once herded into a small cove and penned up there for a food supply. The scarceness of this mammal in Florida Bay, the writer is informed, is attributable to ruthless hunting of it for food by local people who specialized in killing the baby ones because they are tender. Numbers of manatees in the Park area appear to be inversely proportional to their accessibility to the fishing villages of Chockoloskee and Flamingo.

Manatees are more often seen in turbid water than clear, and one seldom is able to count them with confidence. However, Bangs (*op. cit.*: 785) reported eight alleged to have been seen together in the Sebastian River, and Krumholz

(1943: 272) counted five in a group off Sanibel Island. We have not seen them in the Park in such herds to be certain of it. However, both Parker and Watson have had the experience, while cruising along at a good speed through a part of

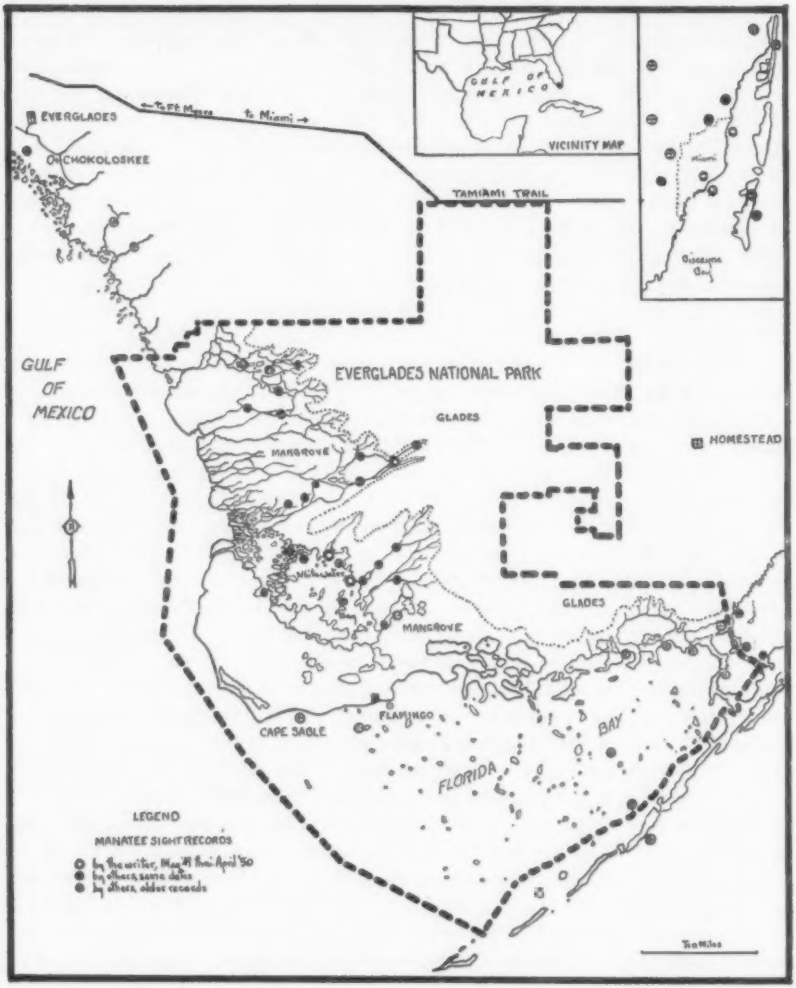

FIG. 1.—Map showing sight records of manatees.

Whitewater Bay, of suddenly seeing upheavals of water and mud marking the rapid departure of manatees going in several directions.

A curious feature of manatee numbers is their abundance in the heart of Mi-

ami. Here they seem to be protected alike from destruction by vandals and by hunters of illegal meat. Also, that is where waste waters are vented into the Miami River. During the few days of cold weather which occur some winters, the manatees congregate about one of these waste water outlets. Turbidity effectively concealed the beasts except when they were at the surface to breathe, and the writer could not make a direct count. However, between 7:45 and 8:45 A.M., on November 27, 1949, a tally of the number of times a head was raised for a breath came to 183. This was looking down river from the east rail of the Miami Avenue Bridge. Although five was the largest number at the surface at one time during the count period, about 10:15 that same morning the writer counted ten at the surface at once. There were undoubtedly many more than ten present.

Habitat.—Bangs' (*op. cit.*: 785) information about the manatee in the Indian River area suggests that this animal favors rather shallow salt-water bays and fresh or brackish waters of sluggish, coastal rivers. Our observations amply sustain this. Of our 53 sight records of manatees for the Park area, and 30 more for south Florida generally, virtually all are for such situations. In the Park area sight records are usually obtained as one is traveling during the daytime along one of the rivers close to a bay. There is a commotion in the water, then a series of up-boilings of water appears at the surface and moves off in a line marking the departure of the manatee. These up-boilings of water are caused by the vertical motion of the tail of the manatee. Sometimes the animal is seen at the surface, but more often not. If not, the observer must judge from the situtation and action whether he has met with a porpoise or a manatee. These encounters are often close to a fork or an island or an open bay where the manatee has some opportunity to dodge rather than run straight away. When encountered in an open bay, a manatee is likely to be just off the point of some peninsula or island around which a wind current sweeps and makes a deep place. Seven feet is deep for these bays and streams. The bays are mostly mud bottom and the streams are characteristically swept clean to the bed rock in which their beds are cut. Bays and streams are both rather turbid most of the year.

Exception to this manatee preference for rivers and shallow bays is Rohn's observation of one seen close to the beach on the ocean side of Key Biscayne at 2:30 P.M. on March 8, 1950. The life guard there told him that this was not an infrequent occurrence. The same month a life guard at the Dade County Haulover Beach Park told the writer that in his two and one-half years there on that Atlantic ocean beach he often saw porpoises, but only twice had he seen manatees, once in the summer of 1949. An additional exception is Krumholz' (*loc. cit.*) record of five manatees on the seaward side of Sanibel Island, Lee County, June 30, 1940. In all three instances these animals were in shallow water no more than two miles from an inlet, and in at least two cases they were protected from the open sea by an offshore bar. Somewhat farther from base was a manatee observed by Jack O. Wilkinson of Tavernier off the south side of Plantation Key, Monroe County, about April, 1947.

The number of sight records that we have of manatees in rivers near to salt

water bays and in salt water bays near the mouths of rivers suggests some affinity to the area of fluctuation between fresh and salt water. It is rather well known locally that manatee occur in Biscayne Bay and frequent the Miami River in the heart of the city. Just how far they go up the canals which connect with the Miami River and Biscayne Bay is not known. The MIAMI HERALD reported four that were trapped in Twin Lakes at Miami Springs, on August 10, 1945, by the closure of the outlet to the Miami River. This place is eight miles up the river. Winte told me of seeing two manatees in a rock pit which is nine miles up the Biscayne Canal from the Bay. Jay A. Weber saw two in a rock pit connected with the Oleta River across the highway from Greynolds Park. On February 13, 1946, according to the MIAMI HERALD, two manatees were hoisted over a dam in the Little River Canal about 2½ miles up from the bay. Burton Hunt of the University of Miami told me of seeing a manatee several miles up the Coral Gables Canal about March, 1950.

Congregations of manatees observed by the writer a quarter mile up the Miami River have been predominantly individuals which were coated with brownish or greenish marine growth and studded with a barnacle here and there over the body. Among them, however, were some which were less encrusted and still others which were quite clean of marine growth and showed their natural dark gray skins. One individual's skin showed scraping marks rather well all over its back (December 6, 1949), as if it had been thoroughly scraped by a conscientious attendant. This general disparity of encrustation suggests that some had been spending the bulk of their time out in the salt water bay and others had been haunting the fresh waters up river.

Reproduction and parental care.—When Thomas Barbour (1937: 106) published the first description of the birth of a manatee, he acknowledged that the information was recorded for him some time after the event occurred, and he did not publish the date of birth. Of interest, therefore, is a MIAMI HERALD story of May 24, 1930, concerning this incident. It states that on the day before a baby had been born to a pair of manatees in the Miami Aquarium a few minutes before sunset, and that the HERALD had been advised of the birth by telegram a few minutes after its occurrence. This account relates that the mother took the baby to the surface on her "shoulder" for air, and that the male parent was so solicitous that when the female did not take the baby up for air soon enough to satisfy him, he prodded the female with his tail. It notes that the birth had been expected by the proprietor of the aquarium since January. Weights estimated for the mother and baby were 850 and 40 pounds, respectively. There are points of disagreement here with the account provided Barbour, and because of the circumstances mentioned, the present account is believed to be more nearly accurate.

Lowe enables us to record here the second known birth date for a manatee. On August 18, 1946, at 11:15 A.M., a manatee gave birth in a salt water pool where she was kept for exhibit at the "Theater of the Sea" on Windley Key, Monroe County. This was after she had been kept alone in the pool since March 19, 1946, and a gestation period of at least 152 days is, therefore, indicated.

Interestingly enough this approximates the period of expectancy noted in the paragraph above.

Mrs. Harry E. Prescott, cashier and guide, witnessed the birth and gave the following account to Lowe who carefully recorded and preserved it: ". . . I heard a loud thrashing of water in the cow's pool. I thought she was having convulsions . . . I ran . . . to the pool . . . the cow was on a shallow shelf slapping the water with her tail. . . . Suddenly she rolled sidewise, and when she righted herself, she had the baby calf on her back. She kept the baby in this position completely out of the water for 45 minutes. Then she submerged gradually until all but the baby's nose was under water, when she rose to the surface again. This action was repeated at a gradually increasing tempo for a period of two hours or more. At the end of this time she ducked the baby completely under the water, but rose again very quickly, each time remaining under water a little longer. This action was of approximately two hours duration also. The calf was able after this period to stay under water for quite some time, but not nearly so long as the mother cow which periodically brought the calf to the surface for breathing. The calf was estimated to weigh 40 pounds.

"After this birth the mother cow rapidly lost weight and . . . became sluggish . . . refused to eat, and finally died February 4, 1947. By this time the calf habitually came up for air four times more frequently than the mother. It sometimes put its flipper through the mother's in much the same manner as humans link arms, and the two swam about the pool. Neither cow nor calf surfaced while nursing. The cow either lay quietly on the bottom or fed from place to place over the bottom of the pool while the calf nursed. When lying on the bottom, the cow turned slightly on one side, and the calf came in under the flipper where it meets the body, the teat being located there. The cow habitually placed itself between the calf and any disturbance or intrusion." In spite of efforts to feed it, the calf died six days after the old one, at the age of 177 days. The cow originally came from the Biscayne Canal near 131st Street in North Miami. Both skeletons are in the collection of the Department of Zoology, University of Miami, at Coral Gables, Florida.

A number of field observations are available. M. B. Parker observed adult manatees with babies in Park waters on July 28, 1949, and February 25, 1950. The first was estimated to weigh 100 pounds, and the second was estimated to be only three feet long. Semingsen saw a baby manatee swimming close beside its mother in the clear water of Avocado Creek in the Park on January 3, 1948. On February 18, 1950, the writer observed a baby manatee estimated to be very close to four feet long. This one was rising below the Miami Avenue Bridge in the Miami River, and was observed from directly above at a distance of ten or eleven feet. It appeared to be associated with only one of the several adults present, since none of the others had the same density of marine growth on them. It was rising more often than the adults. On April 1, 1950, at this same place a baby manatee estimated to be three feet long and to weigh 40 or 50 pounds was observed. It was in the company of three adults. As the writer sat still on the seawall within three feet of the water, at least two of these adults approached

to rise within one to five feet of him (horizontal meas.) to breathe, and raise their eyes above the water to scrutinize him. One did this about five times in the course of an hour. Another, larger and seemingly broader of muzzle, approached to about five feet in that manner twice. The remainder of the risings of the adults was at a distance of 12 to 25 feet from the writer. Manatees watched at this place on ten other occasions sometimes moved farther away, but this was the only occasion when a manatee approached the observer, and this action appeared to represent concern for the safety of the calf.

Krumholz (*loc. cit.*) observed a baby manatee, which he estimated to be 3½ feet long, off Sanibel Island in company of adults on June 30, 1940, and comments, "From his actions it appeared that the bull was trying to divert our attention from the cow and calf, although while we were in the vicinity, he did not move more than a quarter-mile from them." Parental solicitude for the young seems to be observed in the manatee whenever there is opportunity for it.

Nelson's (1916: 465) correspondent from Ponce Park on the Indian River, Florida, wrote on June 20, 1916, that a manatee with a calf about three feet long was lingering about his dock. On September 22, 1947, the MIAMI HERALD carried a story of a baby manatee which had been washed ashore at Fort Lauderdale on the 17th from the inland waterway by a hurricane. It was alive, and the photograph accompanying the story showed a man holding the baby upright before him by the flippers. By comparison with other objects in a glossy print of this picture, the following sizes were carefully estimated: total length 36 to 42 inches, greatest width of tail 12 to 13 inches, weight about 60 pounds.

If these records of young estimated to be less than four feet are considered to be good breeding records, i.e. observed soon after birth, they suggest that manatees have a very long breeding season, from December through August apparently, or that perhaps their breeding is unrelated to season.

On the mammaries of a 6-ft., 8-in. female manatee, Garrod (1877: 141) remarks, ". . . my observations entirely agree with those of Dr. Murie so far as the mammary development is concerned. No teats were to be found, nor any decided indications of their whereabouts. Just internal to the ventral insertion of the limbs there were one or two slight mamilliform thickenings of the integument, which had no deeper-seated glands apparently connected with them." The writer scrutinized a live female of similar size in the Miami Aquarium November 19, 1949, without being able to discover any suggestion of mammae. Doubtless these were non-parous females. The teats of the parous manatee which Lowe examined measured 1.5 and 3.5 inches in length, and were located snugly adjacent to the ventral insertion of the limbs.

One of the problems which perplexed the writer, before he had seen the urogenital openings of both sexes, was how to distinguish the sex of a live manatee if the urogenital openings were observed. Since little help was found in the available literature, and urogenital openings of Hill's (1945: 157) dugongs do not correspond exactly in either sex, it seems worthwhile to record their location in the manatee. The urogenital opening in a live 6½-foot female was observed to be about five inches anterior to the anus and 15 inches posterior to the umbili-

cus. The urogenital aperture of a live 6-foot male was observed to be about 17 inches anterior to the anus and only two inches posterior to the umbilicus. Both were studied at close range in aquaria.

Breathing.—Breathing is the activity of a manatee that one observes most. With the advantage of the controlled conditions of an aquarium pool G. H. Parker (1922: 128) carefully studied the breathing of three Florida manatees. Their habit was to rest at the bottom, to rise to the surface for a breathing period, then to sink quietly to the bottom again. The resting periods submerged were much longer than the breathing periods at the surface. From one to five breaths were taken during a breathing period. For the largest animal with which he dealt, a female about ten feet long, periods of submergence averaged 12 minutes, breathing periods 77 seconds, and number of breaths per breathing period 2.6. For the smallest, an immature about six feet long, periods of submergence averaged 4 minutes and 37 seconds, breathing periods 49 seconds, and number of breaths per breathing period 1.7. Parker concluded that, ". . . the larger the manatee, the longer it can stay under the water, the longer it breathes at the surface, and the more breaths it takes while breathing."

The manatees whose breathing Parker studied had been in captivity nearly a year and had become extremely tame. Very rarely if at all has the writer seen the back of a free, wild manatee break the surface of the water before the muzzle when the animal is rising to breathe, as Parker reported for the captive ones. He reported their manner of breathing for periods when they were completely undisturbed and quiet. Records of the breathing of an undisturbed but free, wild adult, and of a baby manatee will consequently have some interest. So, possibly, will a few records of the breathing of free, wild manatees when violently active.

On March 26, 1950, a lone adult manatee rising undisturbed in nine feet of water in an open salt water bay between 8:18 and 9:18 A.M., was observed from the shore at a distance of 50 to 70 yards. As is the practice in the waves of an open bay when the breeze is fresh, this manatee raised its head quite high for each breath, making easy an accurate count. Exhaling, nevertheless, often raised a low fount of spray, particularly on the first breath of any one breathing period. Intervals between risings were 7, 9, 9, 8, 11, and 9 minutes for the even hour. Breathing periods were noticed to range between 30 and 60 seconds. Number of breaths per breathing period were 3, 3, 2, 3, 2, 3, and 3. At the ends of three of the breathing periods the manatee rolled; at the ends of the other four it did not. Perhaps it is well to describe the roll and the two different kinds of breathing periods observed. During one type the head and back of the manatee become visible at the surface and remain more or less so throughout the breathing period. For each breath it raises its head somewhat above the water. After each breath it drops its head back into the water. After the last breath it may or may not roll. Rolling consists of leaving the surface head foremost, the back following and tail coming up and disappearing last. During the other type of breathing period the manatee remains somewhat below the surface, puts its head up for each breath and pulls it down out of sight after each. The last breath of such a breathing period is distinguished only by the fact that it is followed by a

long, submerged resting period. There is no roll, and it may be that the animal slips back to the bottom tail first, the easier to assume the drooping pose supposed to be characteristic of their rest. This latter type of breathing period is used the more frequently, even in deep water such as 9 to 12 feet, by free, wild manatees.

Between 8:56 and 9:56 A.M., April 1, 1950, the writer recorded the rising of a free, wild baby manatee. In company of three adults it rose in turbid water, perhaps eight feet deep, and at a distance from the observer varying between three and eighteen feet. It was estimated to weigh 40 or 50 pounds and to measure 3 feet in length. The time of each appearance at the surface was recorded, occasionally to the nearest second but usually to the nearest five seconds. During the even hour it rose to breathe 68 times. The intervals between risings ranged from 10 to 125 seconds and averaged 50.2. The breathing periods (time at surface) are estimated to average two seconds and not to exceed five seconds. The number of breaths per breathing period apparently was always one. Unlike an adult, which habitually rises gently to breathe without disturbance to the surface, the baby bobbed freely to the surface, caused a little ripple, and sometimes even rolled unsteadily a bit from side to side.

An adult in company of others, but distinguished by a skin blemish on its head and somewhat also by the habitual explosiveness of its exhaling, was observed closely enough for a breathing count from 11:54 A.M. to 12:34 P.M., December 8, 1949. It was rising from the bottom in more than seven feet of turbid water and facing a 2 m.p.h. current (est.). As was characteristic of manatees observed at this place, this one returned to the bottom after each single breath. The time-spacing of the breaths, however, shows distinctly at first a pattern much like what it would be if the animal stayed at the surface for breathing periods. Intervals between rising, in minutes and seconds: 1:00, 2:20, *5:15*, 0:30, 1:00, *5:42*, 0:55, :113, *4:05*, 1:30, *5:30*, 0:45, 1:00, *2:55*, 1:25, *3:10*, 2:24, and 1:01. Italics indicates the longer intervals which presumably correspond to the submergence periods described above.

The breathing of a seven-foot (est.) manatee raised in Whitewater Bay at 9:40 A.M. on May 3, 1949, and pursued for ten minutes by speedboat, was clocked with a stopwatch. The five intervals between breaths obtained during this pursuit, 30, 40, 45, 40, and 35 seconds are not consecutive, but random and typical. Another manatee aroused and pursued at 10:50 the same morning, in Watson River near its mouth, was larger and more elusive, never showing more than the tip of its nose. The only breathing interval obtained in this case was 52 seconds.

Resting posture.—The strange resting posture of back humped up with the head and tail dangling, the tail curled under so that its dorsal surface lay on the bottom, has been reported for captive manatees by Brown (1878: 296), Miss Crane (1881: 459), Murie (Crane, *loc. cit.*) and Parker (*op. cit.*: 128). Apparently this habit is not confined to captives, for when murky waters of the Miami River cleared enough, about noon on December 6, 1949, it enabled the writer to see a free, wild adult in this posture. In a moment, however, the manatee was disturbed and moved away. Because of the horizontal resting posture of the

two young manatees under her observation in an English aquarium, Miss Crane (*loc. cit.*) attempted to explain the peculiar resting posture of earlier studied manatees as a reaction to injury or sickness. The resting posture of a captive manatee about 6½ feet long, observed in the Miami Aquarium June 25, 1949, which, like the pair observed by Miss Crane, was kept in water only 2½ feet deep, suggests that confinement in such shallow water may induce an atypical resting posture. With tail and head somewhat thrust upward, this one rested belly up. Recording of its breathing intervals was somewhat disturbed by visitors, but the two small series obtained are presented here because they resemble the usual pattern and show that the belly-up position corresponds to the normal submerged resting period. They are in minutes and seconds and the seven italicized intervals represent times when this manatee gently rolled over to rest belly up. 0:24, 0:39, 0:41, 0:45, 1:39, *3:39*, 0:33, 0:18, *1:11*, 0:17, and *2:16*. *1:56*, 0:31, 1:06, *1:48*, 0:35, 0:34, *2:31*, 0:29, 0:42, and *1:26*.

Size.—Adult manatees which have been measured by a biologist seem to be very few. Bangs (*op. cit.*: 784) measured an old female which was 11 ft., 4 in. long, and writes, "The Florida manatee grows but little larger than this female. The two largest that I ever heard of were two caught in the St. Lucie River by Mr. August Park of Sebastian, Florida. One in August 1880, that measured 13 ft., 7 in. long, and one in June of that same year that measured 12 ft. long . . . ." Gunter (1941: 61) records from Texas a male 15 ft., 3 in. long. These are apparently exceptionally large individuals. Manatees observed by the writer appeared to conform much better to the sizes reported for a series of five on the Florida west coast by Cahn (*op. cit.*: 222): "6 ft., 8 in.; 7 ft., 2 in.; 7 ft., 2 in.; 7 ft., 10 in.; 8 ft., 2 in.; and 8 ft., 5 in."

Lowe's series of measurements of the female whose reproduction was reported on above appear to be the only such data available for a manatee known to be parous. Leigh provided measurements of a live six-foot male Florida manatee. These are presented (Table 1) with some data on Gunter's 15-foot Texas manatee, a captive from Florida studied by Conklin (True, 1884: 117), and a "*Manatus americanus*" studied by Garrod (*op. cit.*: 137). Measurement is given in inches.

Weights are rare. Anthony (1928: 554) recorded a 7-ft., 6-in. male Florida manatee which weighed 432 lbs. Conklin (True, *loc. cit.*) gave 450 lbs. for the weight of a 6-ft., 9½-in. Florida manatee. Gunter's 15-footer from Texas was said to have weighed 1310 lbs.

Intelligence.—Because of its placid manner, its expressionless face, and the apparent simplicity of its existence, the intelligence of the manatee is ordinarily under rated, and two different persons who have kept a manatee for exhibit have explained to the writer that the animals are stupid and uninteresting. However, in both of these cases the animals exceeded nine feet in length when taken and were kept in large aquaria where they could easily remain away from intimate contact with their keepers. In two other cases a manatee less than six feet long was taken and kept in a small pool where intimate contact with the keeper and visitors was almost unavoidable. Moreover, the animal was fed by hand more or less all day for the diversion of the visitors. In one case a female, estimated

6½ feet long when seen in Miami Aquarium June 25, 1949, came at call, rolled over, and curled its tail up to thrust the tip into the air. Each of these acts was separately requested by voice and gesture and rewarded with a lettuce leaf. A male, 6 feet long when seen April 15, 1950, in South Florida Museum, Bradenton, came at call, rolled over, swam away toward the far end of the pool and back, offered its right flipper to shake hands, and reared up against the side of the pool standing on the ventral surface of its tail and holding its body 6 inches clear of the wall by means of its flippers, to "rub noses" with its keeper. This meant thrusting its head about 18 inches above the surface of the water. Although museum manager Lester Leigh tried vainly to persuade the manatee to roll over more than one time for me, he assured me that the animal had been taught to roll over any number of times up to three. Each act was separately called for by voice and motion and rewarded with a lettuce leaf.

Social behavior.—November 27, 1949, Miami Avenue Bridge, Miami River: Several times I saw adults "kissing" each other at the surface. In each case one

TABLE 1.—*Measurements (in inches) of manatees*

MEASUREMENT	GUNTER	LOWE	CONKLIN	GARROD	LEIGH
Sex	M	F	?	F	M
Total length	183	110	81½	80	72
Greatest width of tail	36½	26	20½	19	17¾
Length of flipper	17	16	12	14	—
Greatest width of flipper	—	7	4¾	—	4¼
Tip of nose to vulva	—	68½	—	—	—
Length of vulva	—	5	—	—	—
Genital opening to anus	—	2	—	4½	14
Umbilicus to anus	—	—	—	21	—
Umbilicus to genital opening	—	—	—	—	3
Length of anus	—	3	—	—	—
Anus to tip of tail	—	31½	—	—	25

of the pair made the effort, the other taking it passively. They were very sociable, apparently, four to six lolling together directly beneath me, some overlapping others and almost touching sides in a tight little group. Whereas no manatees were observed to break the surface on the 20th other than to breathe, today, after the sun became warm, broad backs stayed at the surface for a minute or more several times. Also, an individual sometimes thrust its whole head above the water when breathing, and occasionally one rolled high out of the water in a sudden show of quickness and strength. Occasionally a powerful tail stroke unseen below the turbid water boiled the water violently at the surface. These were apparently evidences of play or other social behavior.

December 6, 1949, same place: When three adults were quite visible close together under the water beneath me, the largest bowed up acutely with head and tail down in the well-known resting posture. Then as another appeared to nuzzle the big one's side, the latter suddenly but smoothly swam off downstream. The other two pursued so readily that they scarcely lost contact with the big

one, the one which seemed responsible for the flight appeared to keep its muzzle against the larger one's side about midway in the latter's length. The pursuit quickly disappeared in the turbid water. Two and possibly all three soon reappeared among the others rising close to the bridge, but exhibited only breathing behavior.

December 21, 1949, same place: I have seen one cow-calf association, an eight-foot adult with a five-foot young one following against her quarter. The third time that I saw them come up, they put their muzzles together, the adult muzzled the young one in a rather bovine fashion, except that no licking was observed.

March 26, 1950, Biscayne Bay at 55th Terrace, North Miami: Two individuals rose and put their muzzles together above the surface. Viewed from 50 yards these appeared to be adults, and the "kissing" took place only once during an hour of observations.

Food.—Captive manatees have been fed a great variety of foods. Cultivated vegetable foods which various authors have reported captives eating are cabbage, spinach, kale, baked apples, and celery tops, (Chapman, 1875: 461); clover and alfalfa hay (C. W. C., 1940: 100); lettuce and endives, cabbage, turnip, and carrot leaves, sliced roots of swede turnips and carrots (Crane, *op. cit.*: 459); collards, carrots, light-bread, and particularly bananas (Brimley, 1931: 321).

Plants native to the places where the captive manatees were kept, and which have been accepted as food are *Valisneria spiralis*, *Ceratophyllum*, and *Ulva latissima* for Philadelphia (Chapman, *op. cit.*: 459); dandelion and sow thistle, *Sonchus oleraceus*, for Liverpool, England, (Crane, *loc. cit.*); and *Potamogeton* and heads of *Sagittaria* for Philadelphia (Brown, *op. cit.*: 295). "While confined in the lake it ate all the water growth within reach . . . " near Wilmington, N. C. (Brimley, *loc. cit.*).

Apparently only two authors claim to have observed a free, wild manatee eating. Krumholz (*loc. cit.*) comments, ". . . we sighted five animals feeding on eelgrass along the outer shore of Sanibel Island. . . " Barrett (1935: 217) stated, "The Central American animal feeds entirely, according to the writer's observation, on Pará grass (*Panicum molle*). This plant is one of several grasses that grow on the banks of the fresh-water lagoons and rivers, the roots always remaining in the soil above the mean level of the water and the stems floating out some 6 to 10 feet from the bank. Only the tender vertical tips of the stems are eaten, the portions remaining in the water or forming a mat just above it being never touched." Bridge keeper W. T. Porter, on the 17th Avenue Bridge over the Miami River in Miami, who has for years taken considerable interest in the manatees there, pointed out to the writer a coarse panic grass which grew down to the margin on the river bank, stretching some of its long stolons several feet into the water. The manatees, he said, sometimes ate that grass back as far as they could reach it by thrusting their heads out of the water. He said that he has seen as many as five there at one time eating it. W. M. Buswell identified a sample of this grass as the Pará grass (*Panicum sp.*) of Central and South America which has been introduced as a range grass for Florida cattle. Another author says that manatees in the Indian River area of Florida "are reported to approach

the shore and with head and shoulders out of the water, to feed on heavy grass-like plants hanging from the banks." (Nelson, *op. cit.*: 465).

LeBaron (1880: 1005) alleged that the manatees feed on the turtle grass which is abundant in the Indian River (a salt water lagoon) and are fond of lily pads up the fresh water rivers, and like the wild purslane (*Portulacca grandiflora*) which they can reach on salt marsh banks, and Bangs (*op. cit.*: 787) was informed that manatees will eat leaves from the mangroves in lieu of "manatee grass, . . . a tender, ribbon like grass, the blades of which are about half an inch wide and four of five feet long. It grows with the ends of the blades and the blossoms resting on the water and is found only in a few of the freshwater streams of southeast Florida."

Lamar Johnson, whose work as engineer for the Central and Southern Florida Flood Control District has acquainted him well with water hyacinth (*Eichhornia crassipes*), tells me that when he fished in the West Palm Beach Canal in 1944, '45 and '46, he saw manatees there a number of times and saw them eat the water hyacinth. The manatee raised its head out of the water and ate off the green part of the plant. The bridge keeper where Florida route 84 crosses the south fork of the New River had been on that bridge for 3½ years when the writer talked to him (March 19, 1950), and had seen manatees many times. "When water hyacinth gets thick in the river," he volunteered, "the manatees come up and eat it up." "Roots and all?" I asked. "No, only the top," he responded, "but that finishes the plant." He added, "You'll see a hyacinth turn over and go under, and pretty soon another one. That's sea cows eating them." Lowe's notes on the food given the pregnant manatee mentioned above state, "Various foods were tried, including lettuce, water hyacinths, manatee grass, and eel grass. The cow showed a marked preference for the eel grass and manatee grass. It would eat only the leaves of the hyacinths, leaving the stems and roots. It was also seen to feed on some marine plants in the bottom of the pool."

The available data on amounts of food eaten is interesting. Gunter's (*loc. cit.*) 15-foot Texas manatee was said to consume 60 to 100 pounds of grass, lettuce, etc., daily. Crane's (*loc. cit.*) comment on the quantity of food eaten by the two young Trinidad manatees (male 4 ft., 10 in. and female 4 ft., 8 in.) is a little ambiguous, " . . .thirty pounds being their average daily allowance." That the male, habitually ate his own share and tried obstinately to get at that of the female and that she died while he only gained 4 inches in length in 16 months of captivity, suggest that the diet may have been inadequate.

Relation to cold.—Manatees believed to have been killed in Florida by cold are given in Table 2. Gunter (1942: 89) mentions dead manatees in the Peace River which may include one, near Cleveland, additional to those given in Table 2.

Bangs (*op. cit.* 786) disclosed that manatees were present in the Sebastian River a few months after the freezes of the winter of 1894–95, and Krumholz (*loc. cit.*) noted live manatees in the kill area five months after the 1940 freeze. While this may represent replacement by other animals from areas where the freeze was less severe, it may mean instead that some manatees found deep enough bodies of water to protect them from the cold. In the case of many north

Florida rivers there are springs so large as to constitute small rivers flowing into them. Many of these springs are close enough to the rivers to be readily available to the manatees. These large springs supply water at 70°F. much faster than the air could chill it. The present writer believes that in spite of the $500 fine, killing of the manatee because it becomes entangled in fish nets, and because it is edible, accounts for a great many more deaths in Florida than cold.

Summary.—Evidence indicates that the Everglades National Park contains considerable concentrations of manatee habitat, and that the animals, although they have been persecuted as a source of meat, are widely if thinly scattered over large areas of the Park. Manatee habitat is described on the basis of conditions at places where manatees have been seen by day. Concentrations exceeding ten individuals were observed in the Miami River. Some measurements are given on a freshly dead, nine-foot parous female. The first two birth dates for manatees are recorded, with some notes on parental care. A series of observations of young, estimated to be less than four feet in length, are recorded, and a long breeding season, or a-seasonal breeding, is postulated. Gestation period is, in one instance, at least 152 days. The location of the mammaries and means of distinguishing sexes by the location of the urogenital aperture are described. Breathing of free, wild, adult manatees is found to correspond closely to that of captives reported in the literature. The intervals between breaths of a 3-foot wild, free baby averaged 50.2 seconds. Ability of two captives to perform several simple tricks on request is described. Known manatee food is listed and water hyacinth added. Mortality from freezes in Florida is commented upon, and illegal killing of them is considered to be a more serious drain upon their numbers.

TABLE 2.—*Manatees believed to have been killed by cold*

NUMBER	PLACE	AUTHORITY	DATE
3	Near Palm Beach	Maynard in Bangs (*op. cit.*, p. 785)	1886
3	Sebastian River	Bangs (*loc. cit.*)	Dec. 1894
2	Sebastian River	Bangs (*op. cit.*, p. 784)	Feb. 1895
4	Peace River (mouth)	Cahn (*loc. cit.*)	Jan. 26–29, 1940
1	Caloosahatchee River (mouth)	Cahn (*loc. cit.*)	" " "
1	Caloosahatchee River (upper)	Hamilton (1941, p. 690)	" " "
1	La Costa Island	Krumholz (*loc. cit.*)	" " "
3	South Boca Grande Island	Krumholz (*loc. cit.*)	" " "

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A COMPARATIVE STUDY OF THE MALE ACCESSORY GENITAL GLANDS OF *NEÜROTRICHUS*

BY W. ROBERT EADIE

The species *Neürotrichus gibbsi* is regarded as the most shrew-like of American moles in general characteristics and habits and, with the Asiatic shrew-moles, is often referred to as a form showing a transition between moles and shrews. A comparison of the male accessory reproductive glands of *Neürotrichus* with those of shrews and other moles rather unexpectedly reveals some characteristics of the accessory glands of both groups in *Neürotrichus*.

The general morphology and homologies of the male accessory reproductive glands of the shrew genera *Blarina* and *Sorex* and of the mole genera *Parascalops* and *Condylura* have been established (Eadie, 1947*a*, 1947*b*, and 1948*a*). It is now possible to compare these glands in *Neürotrichus* with those of soricids and other talpids.

The gross morphology of the male reproductive system of *Neürotrichus* in breeding condition is illustrated in Figure 1. The testes and epididymides may occupy cremaster sacs which are present in the breeding condition. In three breeding males the greatest diameter of the testes was 8 mm. The cauda epididymis is relatively large and sections of it reveal the presence of the sperm reservoir common to other mole genera so far examined (Figs. 1 and 2). This structure is

apparently a development of the proximal end of the ductus deferens and is absent in shrews. The distal portion of the ductus deferens is marked by the presence of a large and prominent ampullary gland (glandulae ampullarum) just before it terminates in the dorsal wall of the urethra. Such ampullary glands

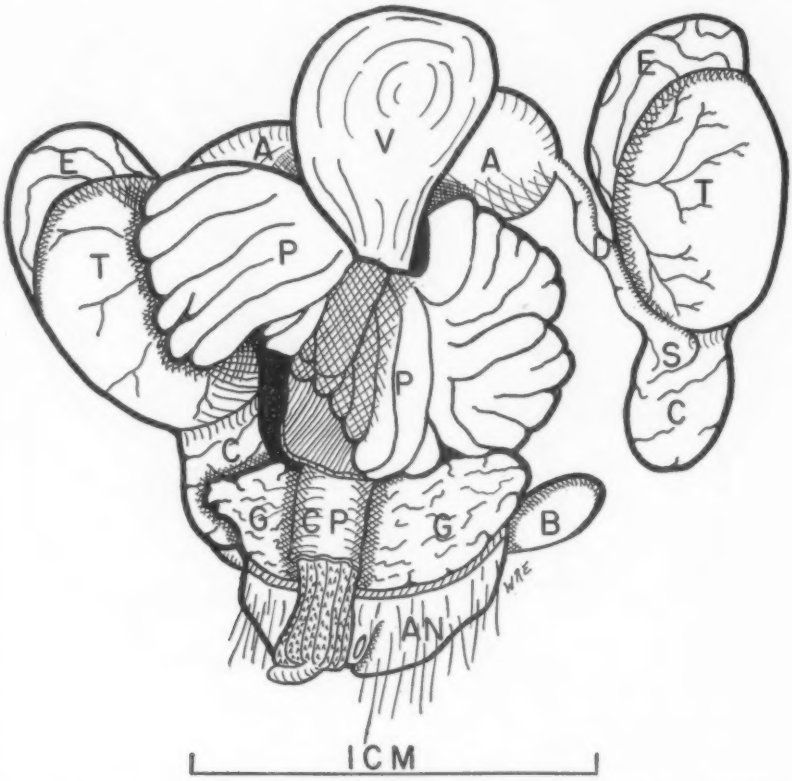

FIG. 1.—Semidiagrammatic ventral view of male reproductive organs of *Neürotrichus*. On the right the testis has been rotated laterally to reveal structures and the bulbo-urethral gland displaced laterally. Note especially the large ampullary glands and the villous character of the prostate lobes. The prepuce has been dissected from the glans penis. A., ampullary gland; B., bulbo-urethral (Cowper's) gland; C., cauda epididymis; D., ductus deferens; E., caput epididymis; G., perineal gland; P., prostate; S., sperm reservoir; T., testis; V., urinary bladder; AN., anal papilla; CP., corpus penis.

are characteristic of the Soricidae (Fig. 3), but none have been found to date in other Talpidae. In its internal structure this gland in *Neürotrichus* closely resembles that of shrews with a thick belt of secreting follicles surrounding the central lumen of the ductus deferens. The proximal enlargement of the ductus that is found in shrews (Fig. 3) is not present in *Neürotrichus*.

The penis is directed caudad with a ventral flexure to its termination at a genital papilla which is separated from a prominent anal papilla by a distinct perineal space as in other moles. The glans of the penis is approximately 3 mm. long in the resting stage, is slightly swollen terminally, and is marked by longitudinal grooves. Its surface is beset with sharp, posteriorly directed, horny

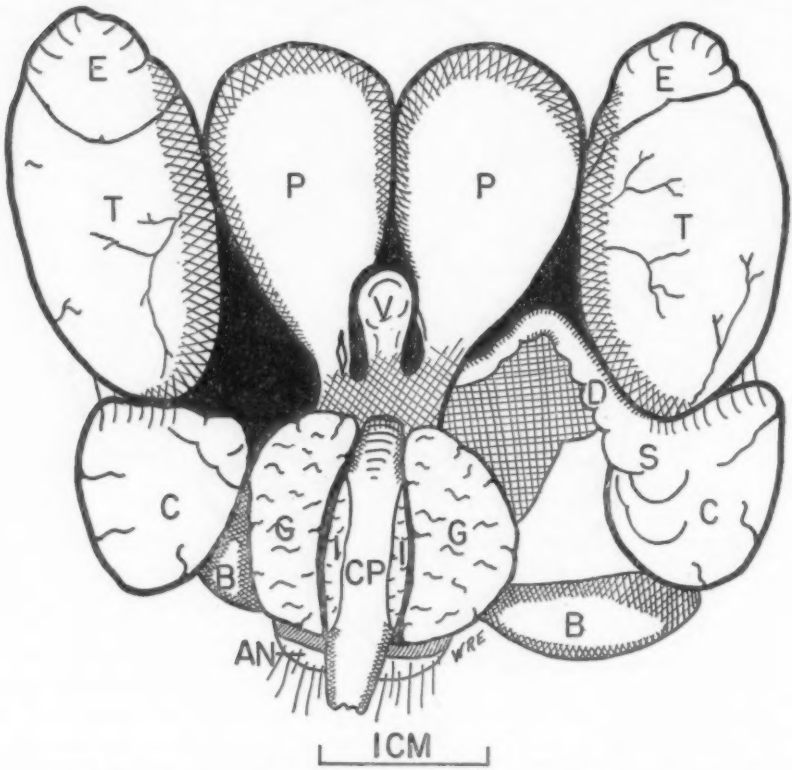

FIG. 2.—Semidiagrammatic ventral view of male reproductive organs of *Condylura*. One testis is rotated laterally and one bulbo-urethral gland displaced. Note especially lack of external lobulation of prostate lobes and absence of ampullary gland on ductus deferens. Urinary bladder (V) highly contracted. I., inguinal glands. Other labels as in Figure 1.

spines. This spiny area of the glans ends abruptly in a truncate ridge beyond which is the urethral opening. A narrowed pointed process projects terminally over this opening. No os penis was found and discrete preputial glands were not noted.

The prostate gland (glandulae prostaticae) lies ventrad and laterad to the neck of the bladder and consists chiefly of two lateral masses or lobes which are

divided externally into finger-like lobules, giving the prostate a villous appearance reminiscent of the prostate in the shrew genus *Sorex*. The lobules are coarser than those of *Sorex*, however, and the mass of the prostate is not relatively so great in *Neürotrichus* as may be seen by a comparison of Figures 1 and 3. In other talpids so far examined the external lobulation of the prostate divisions

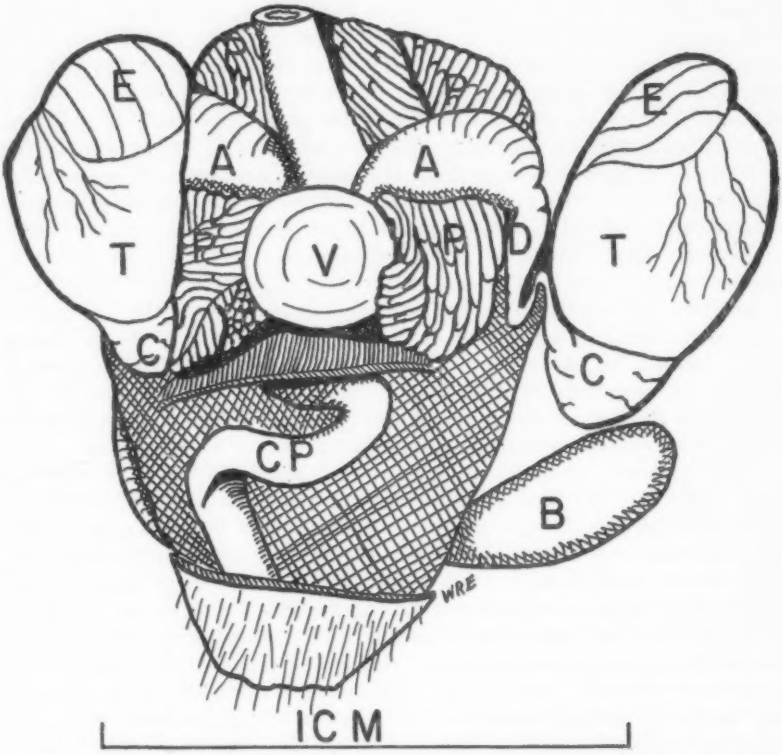

FIG. 3.—Semidiagrammatic ventral view of male reproductive organs of *Sorex*. One testis rotated laterally, one bulbo-urethral gland displaced. Note especially the large villous prostate gland (P) and the presence of ampullary glands (A). D., proximal swelling on ductus deferens. Other labels as in Figures 1 and 2.

is lacking and the gland is more highly organized externally into one or two compact lobes. In *Condylura* there are two distinct lobes (Fig. 2) while in *Parascalops* the two lobes are combined externally to form a median ventral structure (Eadie, 1947*a*). This latter condition is found also in *Scalopus* and in the Old World genus *Talpa* (Kaudern, 1910). In these moles the double nature of the prostate is revealed by dissection and by the arrangement of the ducts in relation

to the urethra. In *Neürotrichus* each of the two lobes empties ventrolaterally by a pair of ducts into the urethra. Ontogenetic studies have shown that the lobes of the prostate in soricids and talpids are homologous with the ventral lobes of the prostate in other mammalian groups for which such data are available (Eadie, 1947*a* and *b*).

It has been observed (Eadie, 1948*b*) that the chief and normal product of the prostate gland in the mole genera *Talpa*, *Parascalops*, and *Condylura* consists of a mass of corpora amylacea (prostatic concretions) which are apparently involved in the formation of an unusual type of copulatory plug. Crushed segments and histological sections of the prostate gland in *Neürotrichus* show that here also they are the principal product of the gland. The alveoli of the gland in the breeding male are filled with a mass of concretions of varying sizes floating in a relatively small amount of fluid. This adds another genus of moles to the list of insectivores known to possess this unusual physiological attribute. Prostatic concretions are of only scattered occurrence in soricids (*Blarina* and *Sorex*).

Cowper's glands (glandulae bulbo-urethrales) in *Neürotrichus* are similar in location, relative size, and general relationships to those of shrews and other moles (Figs. 1, 2, and 3). They are located posteriorly outside the body cavity where one member of the pair lies on each side near the base of the tail, fitting closely against the adjacent muscles. The single duct of each gland extends medially and anteriorly to enter the urethra dorsally at the region of the crus penis. Each gland is a flattened ellipsoid and possesses a layer of striated muscle enclosing a compact, compound tubular gland mass.

Large perineal scent glands are present. Such glands have been described in other moles also (Fig. 2), but are absent in soricids. In *Neürotrichus* they lie just beneath the skin dorsad and laterad to the body of the penis (Fig. 1). The glandular tissue is organized into a median mass which consists of two functionally different portions as in other moles studied. There is an antero-ventral portion of probable sudoriparous origin and merocrine in type, and a postero-dorsal portion of probable sebaceous origin and holocrine in type. The holocrine portion is not as highly organized or as complex as in *Condylura*, but more closely resembles in structure that portion of the gland in *Parascalops*. The gland ducts in *Neürotrichus* terminate posteriorly by a pair of openings situated on a small secondary papilla located on the anterior face of the large anal papilla (Fig. 1). There was no trace in *Neürotrichus* of the two pairs of holocrine inguinal glands that have been described in *Condylura* (Eadie, 1948*a*).

Discussion.—The value of the morphology of the male reproductive system as a criterion for mammalian classification has been demonstrated by Mossman, *et al.* (1932) in the Sciuridae. Thus, a brief consideration of the significance of such morphological data in the classification of moles seems justified.

The genus *Neürotrichus*, with the related Japanese genus *Urotrichus*, has been variously classified within the family Talpidae. Gill (1875) placed them in the subfamily Myogalinae. Thomas (1912) included the two genera with *Scalopus*, *Scapanus*, and *Parascalops* in the Scalopinae where Simpson (1945) has retained them. Various other recent authors have listed them in the Uropsilinae with

TABLE 1.—*Summary of available information on the principal male accessory reproductive glands in talpids and soricids*

GENUS	SEMINAL VESICLES	AMPULLARY GLANDS	PROSTATE GLAND	COWPER'S GLANDS	PREPUTIAL GLAND	INGUINAL AND PERINEAL GLANDS	SOURCE
Talpidae							
Desmana	None	None	1 pair	1 pair	?	?	Kaudern (1910)
Talpa	None	None	1 pair (fused)	1 pair	None	Present	Rauther (1904)
							Kaudern (1910)
Scalopus	None	None	1 pair (fused)	1 pair	?	?	Kaudern (1910)
Parascalops	None	None	1 pair (fused)	1 pair	Few, small diffuse	Large perineal	Eadie (1947*a*)
Condylura	None	None	1 pair (separate)	1 pair	None	Large perineal 2 inguinal	Eadie (1948*a*)
Neürotrichus	None	1 pair, large	1 pair (separate)	1 pair	None	Large perineal	Eadie
Soricidae							
Sorex	None	2 pairs	1 pair (separate)	1 pair	None	None	Arnbäck (1907)
							Kaudern (1910)
							Eadie (1947*b*)
Blarina	None	2 pairs	1 pair (separate)	1 pair	None	None	Eadie (1947*b*)
Crocidura	None	Present	1 pair	1 pair	None	None	Kaudern (1910)
Neomys	None	Present	1 pair	1 pair	None	None	Kaudern (1910)

Asiatic shrew-moles (Anthony, 1928; Tate, 1947). Jackson (1915), in his review of the American moles, pointed out that these arrangements are superficial and unnatural, and disregarded subfamily groupings in the Talpidae. He stated that "The anatomical differences, other than dentition, between *Parascalops* and *Neürotrichus* and each of the other genera of American moles are as great as those between *Condylura* and each of the other genera or even greater," and that "in order to recognize fundamental and consistent subfamilies it would be necessary to raise nearly every genus to the rank of a subfamily." The presence of shrew-like ampullary glands in *Neürotrichus* and their absence in *Parascalops*, *Scalopus*, and *Condylura*, as well as in the Old World genus *Talpa*, would seem to reaffirm this viewpoint. Certainly, on the basis of this evidence from such evolutionally conservative organs as the reproductive glands, *Neürotrichus* seems even more widely divergent from other American moles than does *Condylura* which is rather consistently assigned to a separate subfamily.

Available information on the occurrence or non-occurrence of the principal male accessory reproductive glands in talpids and soricids is summarized in Table 1. It is apparent that data on the condition of the accessory glands in the Asiatic genera of shrew-moles, *Urotrichus*, *Uropsilus*, and related groups, are lacking. It would be quite informative to know whether ampullary glands occur in these genera. Specimens of *Urotrichus* collected by the author near Lake Hakone in Kanagawa Ken, Japan, on December 9, 1945, show no macroscopic trace of such glands, but these specimens are not in breeding condition and, by analogy with our native insectivores, it is not to be expected that such glands would be grossly visible in this stage. Histological sections of the ductus deferens from these specimens show the presence of diverticulae from the lining of the lumen at the point where ampullary glands normally develop in *Neürotrichus*. It is possible that these indicate that an ampullary gland is present in *Urotrichus* at this site in the breeding condition.

Summary.—*Neürotrichus* possesses all the principal male accessory reproductive glands common to other talpid genera so far investigated and these glands show similar fundamental characters and anatomical relationships. In addition, however, *Neürotrichus* possesses a pair of prominent ampullary glands characteristic of soricid genera, but absent in American talpids of the genera *Scalopus*, *Parascalops*, and *Condylura*. This somewhat divergent character of the accessory reproductive glands in *Neürotrichus* would seem to separate them sharply from other American talpids and indicates the need for a reconsideration of the value of current subfamily groupings in the Talpidae in the light of all available morphological evidence.

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THE BACULUM AS AN AGE CRITERION IN MINK

BY WILLIAM H. ELDER

Explorations in the dynamics of mammalian populations require either that a marked group of individuals of a species be followed or that each year a random sample of the wild population be classified as to age and sex composition. For many species which are difficult to live trap, such as fox, mink, and otter, an understanding of variations in reproduction or in juvenile survival responsible for ups and downs in abundance may never be accomplished through tagging studies. It is especially important that reliable criteria of age be discovered for these species in order that the age composition of the harvest can be determined. The significance and application of this type of information has long since been discussed by Leopold (1936).

The use of the baculum as a means of distinguishing age groups in several species of mammals has been pointed out in recent years. Length, weight, and volume of this bone have been found to increase with age, at least through puberty, in the species reported; concomitant changes in conformation have also been described. Deanesly (1935) showed that in the weasel (*Mustela erminea*) first year animals could readily be distinguished from older animals by the lesser weight of the baculum. Wright (1947) found no overlap in the weights of bacula from juvenile and adult long tailed weasels (*Mustela frenata*) of several subspecies. Wright and Deanesly agree that this age criterion is reliable in these

two species of weasels until the onset of puberty at approximately eleven months of age. Wright has also shown that in his material gathered from animals of known age, conformation alone is a reliable criterion of age. The value of weight, length, and shape in differentiating probable age classes in otter (*Lutra canadensis*) and beaver (*Castor canadensis michiganensis*) has been discussed by Friley (1949*a*, 1949*b*) along with a description of the changes in conformation correlated with increasing age.

Materials and methods.—This study reports an examination of 242 bacula from ranch mink (*Mustela vison*) of known age. These bones were prepared by the method described by Friley (1947) from penises gathered during three successive pelting seasons at Lynwood Fur Farms. The cleaned bones were uniformly dried for several months before being weighed to the nearest milligram on a torsion balance. The length was then determined by placing the crooked, distal end against a block attached at the zero point of a millimeter rule, as in using a standard fish measuring board. Length to the nearest millimeter was recorded.

Morphology of the baculum.—The shape of the penis bone in mink (Pl. I) is similar to that of other members of the genus *Mustela*—roughly J-shaped with a sharp crook at the distal end. The urethral groove extends along the ventral surface of the distal half of the bone and deepens as it approaches and continues around the periphery of the J-shaped tip.

The great depth of this groove gives the bone a cross-sectional shape of an inverted V anywhere along its distal half. The basal half has a cross-sectional shape of a triangle, with apex on the dorsal side. Each side of this triangle is somewhat concave, but the degree of concavity decreases with age as the bone becomes more massive.

The baculum is never exactly bilaterally symmetrical for the urethral groove does not encircle the distal end in the median sagittal plane, but slightly to the right, thus making the bone at the left side of the urethral groove slightly but distinctly longer than that on the right. This assymetry is clearly visible in the bones shown in Plate II.

The proximal end of the baculum (point of attachment of the *corpus cavernosum penis* as described by Miller, 1948) is very distinct in all but a few sexually immature animals, and is somewhat triangular in cross section but greatly compressed laterally, with the apex always dorsal. It elongates and becomes roughened only after sexual maturity, that is, in animals one and one-half years of age or older.

Age changes.—Figure 1 shows that there is a great range in the weight of the baculum even among sexually immature animals of the same age. Even though all juvenile mink were approximately seven months of age when pelted, penis bones from some are two and one-half times as heavy as those from others. The frequency distribution of each year class shows about the same magnitude of variation. In spite of this fact, there is actually little overlap in the weight of bacula from juvenile as compared with adult mink. This bone does not reach its full development in the first year following sexual maturity, but seems to increase considerably in weight in succeeding years. Material from old mink must always

be scarce in the wild or on the game farm where they are pelted as soon as their breeding vigor declines. Hence, only seven bones from animals three and one-half to five and one-half years of age were available. Although too few to plot as a frequency distribution, their weights ranged up to 568 mg.

Figure 2 shows that the frequency distribution of the lengths of the bacula parallels closely the distribution of the weights as previously discussed. That is to say, an increase in length as well as weight occurs as sexual maturity is reached.

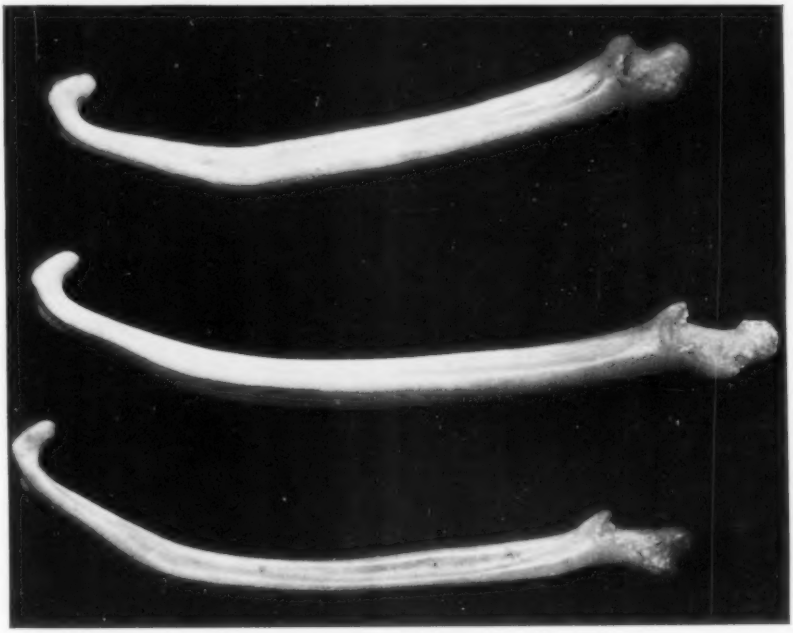

PLATE I

Conformation of the baculum of mink, × about 2½

While both length and weight increase with greater age, the increase in weight is much more marked.

The age changes in conformation of the baculum are more apparent than those in weight and length. Examination of Plate II will reveal that bones from juvenile mink are considerably less massive, and have very small, poorly developed proximal ends—sometimes the end is not morphologically distinct from the shaft. In the older groups the bone is considerably heavier-shafted and the proximal end is highly developed, being actually much longer as well as roughened and with distinct tuberosities. This end becomes even more massive and somewhat smoother with great age, but it is dubious that bones of more than two age classes

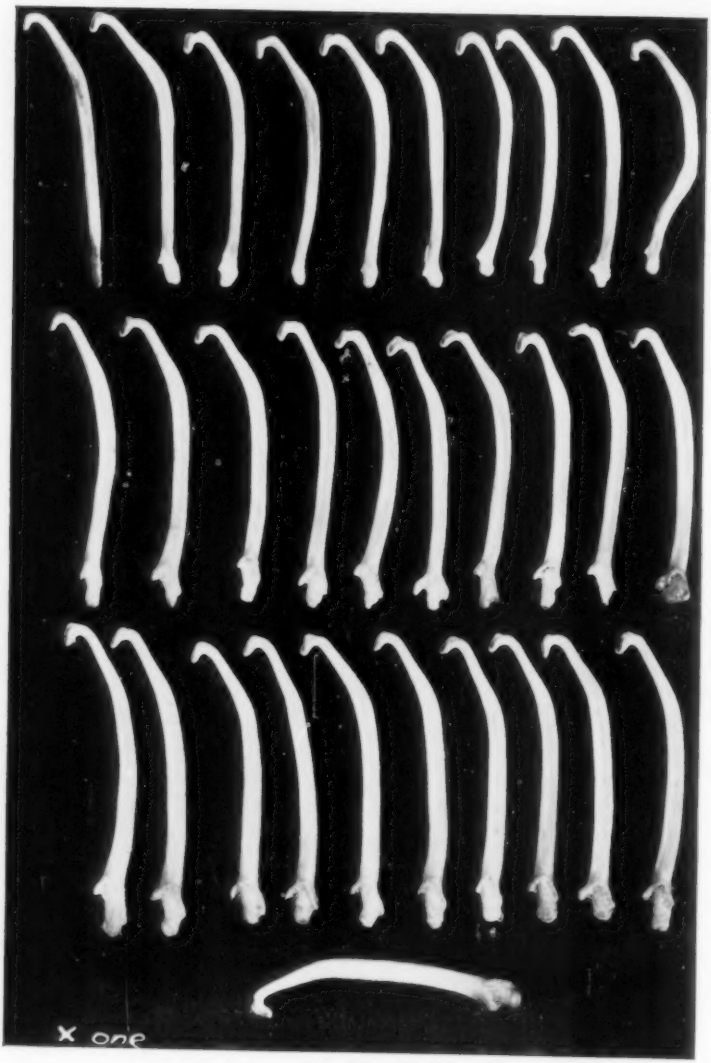

PLATE II

Age changes in the baculum: juveniles at top; one and one-half-year-olds in middle row; two and one-half-year-olds in bottom row; five and one-half-year-old at extreme bottom. All × 1

—juvenile and adult—can be accurately separated by conformation, weight, or length.

Measure of reliability as an age criterion.—Examination of Figures 1 and 2 shows clearly the increase in weight and length of the baculum with increasing age. Statistical analysis showed a high correlation between weight and age (r = .849), but a much poorer correlation between length and age (r = .205). It is obvious, therefore, that weight is a much more reliable and useful age criterion than is length. It is also evident that the degree of overlap in weights of bones from mature mink (age $1\frac{1}{2}$–$5\frac{1}{2}$ years) is too great to permit classification of bones of unknown age into more than two groups: juvenile animals (less than one year of age) and older, or sexually mature animals.

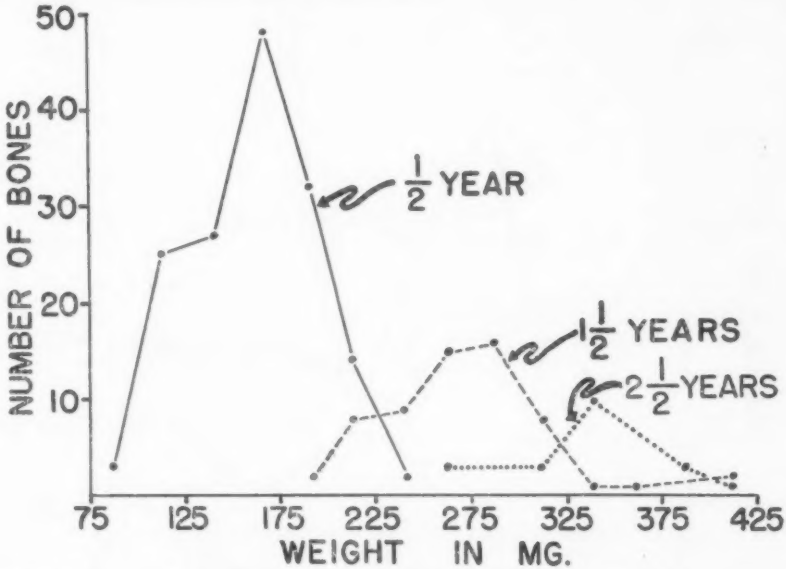

FIG. 1.—Frequency distribution of weights of bacula from 234 ranch mink of known age.

The frequency distribution of the weights of the 152 bones from juvenile mink compared with the 82 bones from mink one and one-half to two and one-half years of age is shown in Figure 3. To test the accuracy of using this figure for predicting age from weight, the mean and standard deviation of the weights of the bones from each group were determined. For the juveniles this was found to be 159 mg., S.D., 33.3; for the adults it was 291 mg., S.D. 47.1. That there is no overlap in these means ± one standard deviation indicates that age may be distinguished by weight alone in 66 per cent of the cases. That there is some overlap in these means ± two standard deviations indicates that age cannot be distinguished in 95 per cent of the cases as we should desire for such a criterion. Actually, classification of an entire group of bacula collected at random could be accomplished with 85–90 per cent accuracy.

By eliminating bones of 196–226 milligrams, that is those falling withing the region of overlap of two standard deviations (from the mean of each age group), accuracy in determining the age composition of a mink harvest can be increased to 98 per cent. With such a criterion one should be able to detect significant year to year changes in the production of young in the population and thus have a means of discovering whether a population decline in mink is due to over harvest or to decrease in productivity. If the former, changes in regulations and enforcement are indicated, if the latter we will be forced to dig deeper into causes.

It may be asked whether bacula from ranch mink would grow at the same rate as in wild mink. While no positive answer can be made to this question it may be

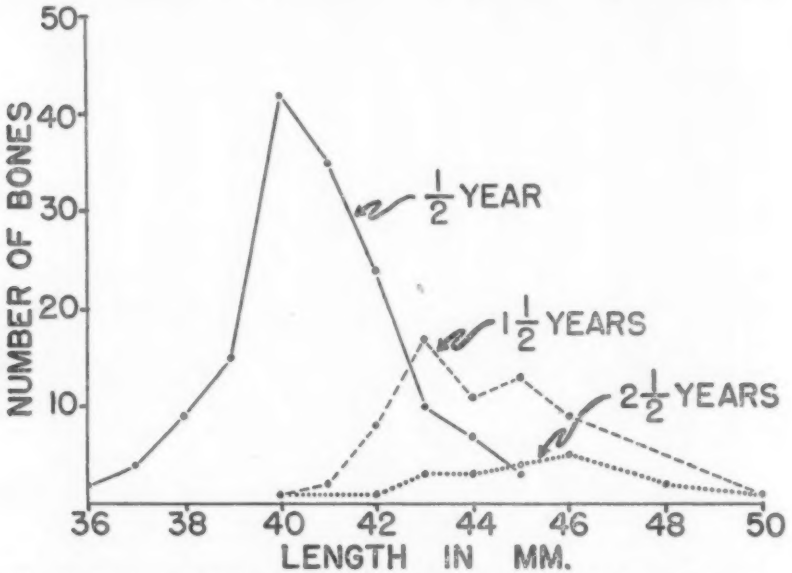

FIG. 2.—Frequency distribution of lengths of bacula from 234 ranch mink of known age.

pointed out that ranch mink are kept strictly out-of-doors and thus are subjected to the same light and temperature as are wild mink at that latitude. They are also fed an optimum diet in order that their pelts may reach marketable condition as early as possible. The reproductive season and age at which sexual maturity is reached seems to have been unaffected by confinement (Hansson, 1947). During the past fur season in central Missouri and Illinois, bones from 17 wild mink were gathered for comparison with ranch mink and their weights fell in the same range; 14 of them weighed between 150 and 255 milligrams and three were heavier, ranging up to 473 milligrams.

Summary.—1. The baculum or penis bone of mink (*Mustela vison*) resembles that of other members of the genus in being a simple, J-shaped shaft slightly but

consistantly asymmetrical at the distal end. The cross-sectional shape of the distal half is that of an inverted V, along the basal half it is triangular with the apex dorsal and each of the sides concave. The base, or point of attachment of the *corpus cavernosum penis* is not always morphologically distinct in bones from juvenile animals, but becomes increasingly distinct and rugose with maturity. As the bone becomes more massive with great age (5 years) all angles become more rounded and smooth.

2. An examination of 242 bones from ranch mink of known age revealed that both length and weight increase with sexual maturity and that weight continues to increase with each succeeding year.

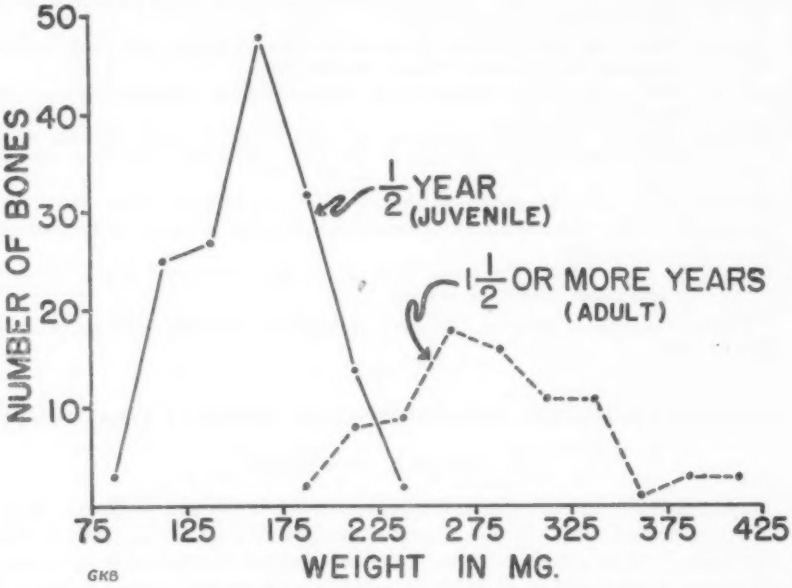

FIG. 3.—Frequency distribution of weights of bacula from 152 juvenile mink and 82 adult mink.

3. Because weight proved to be a better criterion of age than did length, statistical analysis of the weights of the penis bones of juvenile mink as compared with adult mink was made. It was found that bones from animals of unknown age can be classified as either juvenile or adult with 85–90 per cent accuracy.

4. If all bones falling within the region of overlap of two standard deviations from the means of the two age groups—those 196–226 mgm. in weight—be eliminated, the remainder can be classified with 98 per cent accuracy.

5. This criterion of age provides a sensitive measure of adult-young ratios in the harvest and thus supplies a means for determining year to year changes in productivity of mink populations.

Acknowledgments.—Material for this study was made available through the kind co-operation of Mr. Wallace Snyder, Manager, Lynwood Fur Farms, Tibbets, Missouri. This is a contribution from the Missouri Cooperative Wildlife Research Unit; U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation, and the University of Missouri cooperating.

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SMALL MAMMAL RELATIONSHIPS IN AN EPHEDRA COMMUNITY

BY ALBERT C. HAWBECKER

Approximately six miles east of Panoche, San Benito County, California (Panoche Quadrangle, U.S.G.S.), is an area ranging in elevation from 1000 to 1800 feet where, within a short distance, a transect may be run intercepting several changes in small rodent habitat. No attempt is made here to extend either end of the transect to intersect all known habitat situations, as the main concern of this study is the interrelationships of three species of *Dipodomys*, their habitat requirements and limitations, and their relationships to the other small rodents within their areas. It must be emphasized that the conclusions reached here may be peculiar to the pictured and described habitats, and that the responses may be different under slightly different conditions.

The study area rises gently from the west to the east with a slope of 400 feet in the first four miles, then the last half-mile rises sharply, taking in the remaining 400 feet. The first slope is gently rolling, but as the steep slope is approached there are deeper washes, and here the terrain becomes more dissected. In this latter area of transition from the gentle to the steep slopes, as well as on many of the steep slopes themselves, rock outcrops and sharp ridges are common. The soil over the entire area is firm but easily spaded both in winter and summer—

a sandy loam type that is easily dug into by animal life of all kinds and sizes. Thus, on the bases of texture, appearance, and color, the soil over the entire study area is very much alike and would not appear to be a factor in the limitation of the species considered. Rainfall in the area varies around five inches per year.

Going from the lower elevation upward, the plain is first seen to be open with no shrubby or perennial cover, except malpais blue grass (*Poa scabrella*). It is, however, commonly covered with varying stands of the following annuals: red-stemmed filaree (*Erodium cicutarium*), red brome (*Bromus rubens*), and peppergrass (*Lepidium nitidum*), the latter one being found only in the swales. All of these species are green only in the late winter and spring, but provide the main items of diet, whether in the green or seed state, for the small rodents over the entire area. Other annuals are found here, but are seldom recovered in the stomach or pouch analysis of local rodents. As can be seen in Plate I, when higher elevations are reached, or there is some break in the plain, perennial shrubs begin to be found in varying concentrations. On the low rolling hilltops and in some of the broad flats, the low (12–18 inches) snakeweed (*Gutierrezia californica*) is the first one seen (Pl. I). The annuals in this situation are the same as in open ground, except that *Lepidium* is no longer found. Slightly above, or often at the same level as this cover change, the scattered California Ephedra (*Ephedra californica*) can be seen coming in either scattered over the slopes, or interspersed in the *Gutierrezia*. This shrub is from four to six feet high and each one may cover as much as 100 square feet of ground space. Slight breaks in the terrain, change of slope, and narrow draws will materially change the concentration of *Ephedra*, as can be seen in Plate I, upper. It appears however, to be more concentrated on the south and west-tending slopes. It must be emphasized that these changes in vegetation, as is demonstrated at the bases of the steep hills in Plate I, upper, are not always in the form of bands, but the above mentioned changes in terrain may, indeed, put an open site next to the steep hills, a not usual occurrence. Thus, near the bases of the steep hills, where the terrain is more dissected, is a zone where no vegetation or exposure situation is dominant and heterogeneity of vegetation, animal life, and slope and exposure is the rule rather than the exception. As the steep hillsides are reached the *Gutierrezia* drops out, except in the flatter spots, and another composite (*Stenotopsis linearifolius*) is found on the sharp slopes. Flat-top (*Eriogonum fasciculatum*) also comes in on the steep slopes, but is found more commonly on the southwest-facing slopes than on the north-facing where *Stenotopsis* is found in abundance. Both of these shrubs may reach two feet in height and cover 15 square feet of ground space. *Ephedra* varies on the steep hills according to slope and exposure, but is quite uniform in most of the steep places. The east-tending slopes are the most devoid of shrubby cover, but have the usual annuals and some *Ephedra*. *Ephedra* is lacking on flats at these higher levels, but *Gutierrezia* still occurs. Finally, at approximately 1800 feet and on the south-tending slopes, a new, large, perennial plant, Yucca (*Yucca whipplei*) is found. This occurs in varied concentrations among the above mentioned annuals and perennials (Pl. II, lower).

PLATE I

UPPER: Site 1. Most of the site is behind the camera, but the open ground is characteristic of this site. This is a general picture of the area, looking to the south.

LOWER: Site 2. The foreground and the slope to the right are characteristic of this site. The picture is directed to the north.

Factors limiting the distribution of this vegetation, other than slope and elevation with the attendent differences in heat and moisture, are not clear. The rainfall (approximately five inches per year) is less in this area than in the Coast

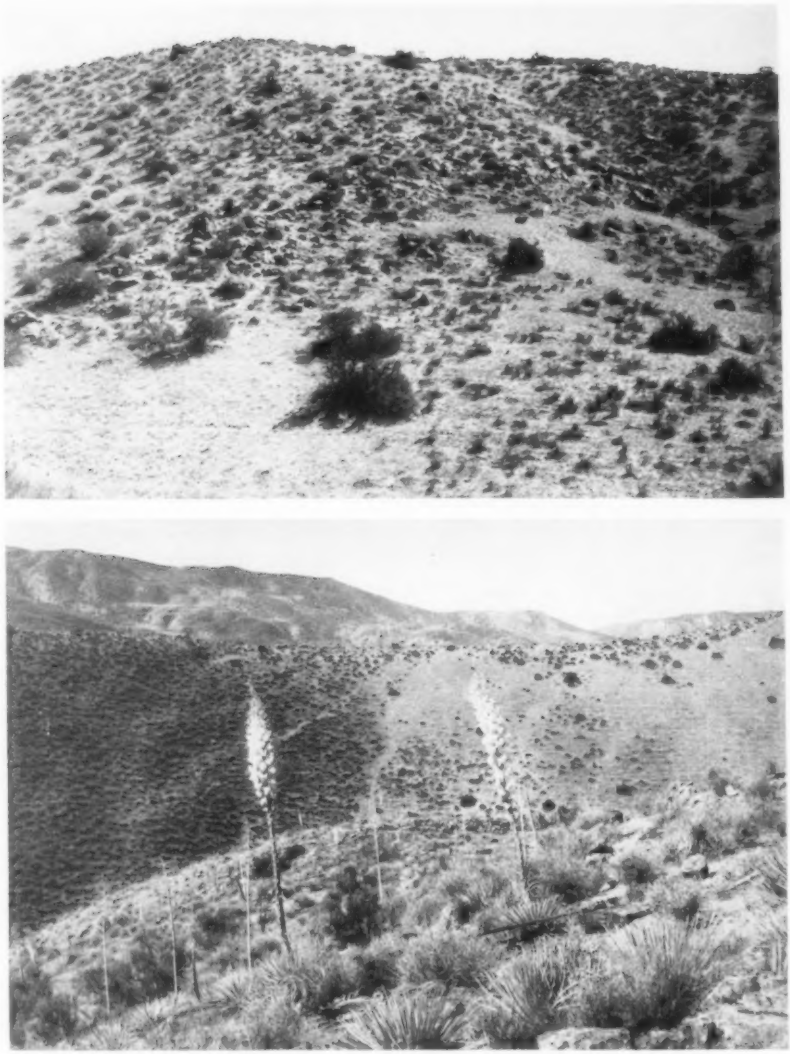

PLATE II

UPPER: Site 5. These steep, brushy, rocky hillsides are the habitat of *Dipodomys heermanni*
LOWER: Site 6. *Neotoma lepida* is found among the rocks in this site

Range proper to the west or the San Joaquin Valley to the east. The pictures give the best concept of the terrain.

As stated, this study is concerned primarily with the interrelationships of the three species of *Dipodomys* of the area, and secondarily with the other small rodents, as well as the relationships of this mammal life to the vegetation, slope, exposure, and other ecological factors.

In a paper on the giant kangaroo rat (*Dipodomys ingens*) Grinnell (1932) discussed the habitat relations of the animal and accorded it almost sole ownership, to the exclusion of other small, seed-eating mammals, of literally square miles of territory. This study was made on open land. Shaw (1934) indicated that only one other small rodent (presumably a *Peromyscus*) was seen on the area during his study of the same *Dipodomys*. His study was also conducted on open terrain. Tappe (1941) found other small rodents rare in the areas where he studied the Tulare kangaroo rat (*Dipodomys heermanni tularensis*). He found further that where these two species were found in the same general locality, the former occupied the more level areas, and the latter seemed to be crowded up on the hillsides. His pictures indicate that this occurred in open country. A third species, the short-nosed kangaroo rat (*Dipodomys nitratoides brevinasus*), is brought into this study. Little information concerning habitat preference is available for this species. Culbertson (1946) studied a related subspecies, the Fresno kangaroo rat (*Dipodomys nitratoides exilis*), and found that other species of small rodents were rare in kangaroo rat habitat, except in brushy areas. He found, also, that this kangaroo rat seemed to be able to share its niche with another kangaroo rat, *Dipodomys heermanni*, as they appeared in about equal numbers in (presumably) the same habitat. Very little has been done on the ecology of the other small mammals in these habitats.

Trapping records and field observations over a period of ten years seem to indicate certain elevational, slope, and vegetational factors that may influence the presence, absence, or dominance of the small rodents in this area. Slight changes in these factors may upset the picture entirely so that, as will be seen later, slight changes or rearrangements of these factors may even throw many species together within the same half-acre.

Associated species that might be encountered, in addition to the kangaroo rats, are: California ground squirrel (*Citellus beecheyi*), Nelson antelope ground squirrel (*Ammospermophilus nelsoni*), Botta pocket gopher (*Thomomys bottae*), San Joaquin pocket mouse (*Perognathus inornatus*), California pocket mouse (*Perognathus californicus*), grasshopper mouse (*Onychomys torridus*), deer mouse (*Peromyscus maniculatus*), Audubon cottontail (*Sylvilagus auduboni*), and the black-tailed jackrabbit (*Lepus californicus*). Several raptorial birds are present, but only the red-tailed hawk (*Buteo borealis*), the prairie falcon (*Falco mexicanus*), and the barn owl (*Tyto alba*) appear, on the basis of pellet analysis and observation, to be significant raptores. Important predators present are the badger (*Taxidea taxus*) and the kit fox (*Vulpes macrotis*) which observably take a definite toll of the rodents over the whole area; the coyote (*Canis latrans*) and the wildcat (*Lynx rufus*) which are seldom seen either as "sign" or in the flesh; and the weasel (*Mustela frenata*) which is often seen and must take a toll, but has not been observed so doing.

A description of each site will be given to acquaint the reader with specific conditions. Except where otherwise noted all trap sets were on a basis of 25 traps on a half acre, per location per day.

Site 1.—This site is more common on the western end of the area where slopes are gentle and flats are broad but may be found even to the bases of the steep hills and on east-facing slopes. Any sudden change in slope will eliminate this site immediately. There is little soil deposition here, and no shrubs except a few scattered *Gutierrezia*. The three prominent annuals *Bromus*, *Erodium* and *Lepidium*, and the perennial *Poa* cover the site (Pl. I).

Trapping records within this site are as follows: May 23, 1941, 1 *D. ingens* and 2 *Onychomys torridus*; May 20, 1942, 1 *D. ingens*; August 9, 1946, 1 *D. ingens*; March 15, 1947, 8 *D. ingens* and 2 *Onychomys torridus*; March 21, 1947, 1 *D. ingens* (4 traps); February 19, 1950, 1 *D. ingens* (2 traps); April 12, 1950, 2 *D. ingens*.

Experience has shown that where there is abundant kangaroo rat sign, yet traps catch few or none, the giant kangaroo rat is the species present. Night observation, shooting, and "haystack" building (Hawbecker, 1944) confirm this.

Trapping and observation thus show that in the open western end, and in the open plots close to the hills, *D. ingens* is the only kangaroo rat present. The only other small, nocturnal rodent that appears to be present is *Onychomys*, and as these were taken not far from the adjacent shrubby areas, it is possible that they should not be considered more than transients in the open site. Present irregularly over the open area is the *Ammospermophilus* that comes out only in the daytime, and an occasional *Lepus*.

This finding agrees with Grinnell, Shaw, and Tappe—the giant kangaroo rat is the dominant nocturnal, small rodent where the plain is brushless. The levelness of the terrain does not seem to be as important here as the lack of cover. Trapping and study of the open, east-facing 9 per cent slopes revealed nothing but *D. ingens*. The area in the middle of Plate I, upper, and the background (up to the steep hills) of Plate I, lower, represent *ingens*-dominated territory.

Site 2.—This site is not as well defined as the previous one. It occurs on the flatter ridgetops, even though some of these may be only some of the higher "rolls" in the rolling plain, or it may occur on the gentle slopes, but never on the steep slopes or in the bottoms. It is never rough, rocky, or dissected, and is well out from the influence of the steep hills. The ridgetops are usually well covered with *Gutierrezia*, with or without a scattering of *Ephedra*, while the slopes usually lack the former, but have more of the latter in a widely spaced condition. *Poa*, *Bromus*, and *Erodium* are common here (Pl. I, lower).

Trapping records within this site follow: May 25, 1946, 1 *Peromyscus*; November 13, 1948, 4 *D. nitratoides* and 1 *D. heermanni*; December 3, 1949, 15 *D. nitratoides*; February 18, 1950, 2 *D. nitratoides* and 1 *D. heermanni*; March 4, 1950, 4 *D. nitratoides* and 1 *D. heermanni*; March 5, 1950, 5 *D. nitratoides* and 1 *Onychomys*; April 5, 1950, 3 *D. nitratoides*; May 13, 1950, 4 *D. nitratoides* (18 traps).

Where a few *Ephedra* begin to appear, along the northern and eastern edges of

Site 1, *D. nitratoides* begins to appear. Open spaces between the shrubs are still observed to support *D. ingens*. On the ridges proper, where the *Gutierrezia* is dominant, *ingens* has never been trapped, nor has any sign of it been seen. Cheek pouches of both species contain shelled filaree and red brome seeds so they apparently both forage for and among the same plants. Thus, even though it may feed in the open, the former species retreats to burrows under the *Ephedra*, or stays entirely in the *Gutierrezia*. The latter species has been found only in the open, which makes it appear conclusive that the cover is the determining factor. The giant kangaroo rat is apparently an animal of the open areas, and the dominance it seems to exercise in the open does not carry over to even the more minute shrubby spots within that area. Both Culbertson and Tappe found that the species they studied were adapted to take over the level, open areas when *ingens* did not exist to keep them out. Other small, nocturnal rodents may be established within this site, but the *Peromyscus* and *Onychomys* of Site 1, which may possibly more properly be assigned to this site, are the only ones that appear. *Ammospermophilus* is seen here rarely.

As this habitat approaches the steep hills *D. heermanni* is taken, which accounts for the *heermanni* in the above list. A few of these are taken out in the *Gutierrezia*, but become increasingly numerous as Site 3 is approached. Less than 100 yards from the March 4 and 5, 1950, take, the April 2, 3, 4, 5, 1950, samples on the Site 3 list were taken. This indicates a passing of the dominance to *heermanni*, or at least the loss of dominance by *nitratoides*, for where the *Ephedra* becomes thicker, rock outcrops appear, and the steep hillsides are close by, as in Site 3, the change is very apparent.

Thus, the gentle slopes, ridge tops, smooth terrain, distance from the steep hills, and definitely the shrubby condition make up the habitat where *D. nitratoides* is dominant. Lack of cover subjects it to *ingens*, and steep slopes, as will be shown better later, make *heermanni* the dominant species. Plate I, lower, illustrates the two phases of this habitat.

Site 3.—This site is a continuation of the shrubby ridgetops, but not the slopes, of Site 2, and runs to the bases of the steep hills. Here the low shrubs are in the process of changing from the *Gutierrezia* of the rolling plains to the *Stenotopsis* of the steep, north-tending hillsides. The *Ephedra* may or may not be more numerous, but rock out-crops are common. There is a definite influence here from the steep hills on the southern edge of the site. The ridges at the bases of the steep hills in Plate I, upper, give an idea of Site 3.

Trapping records within this site are as follows: February 17, 1946, 2 *D. heermanni* and 5 *P. maniculatus*; November 29, 1946, 2 *D. heermanni* and 1 *O. torridus*; January 3, 1947, 6 *D. heermanni* and 2 *P. maniculatus*; March 22, 1947, 2 *P. inornatus* and 1 *D. ingens*; February 19, 1950, 2 *D. nitratoides*; March 5, 1950, 2 *D. nitratoides*; April 2, 1950, 2 *D. heermanni* and 1 *D. nitratoides*; April 3, 1950, 3 *D. heermanni* and 1 *D. nitratoides*; April 4, 1950, 2 *D. heermanni*, 1 *D. nitratoides*, and 1 *O. torridus*; April 5, 1950, 1 *D. heermanni* and 1 *P. inornatus* (April 2–5, 10 traps only); April 23, 1950, 3 *D. herrmanni* and 3 *D. nitratoides*.

This site is a transitional area between Sites 2 and 5. In this respect it is similar to Site 4 which is a transitional area between Sites 2 and 5 with the added influence of Site 1, which makes a significant difference. *Ingens* is not found on these ridges, but may be found on the open slopes on either side. In this area neither *heermanni* nor *nitratoides* is dominant, but, as described under Site 2, the coming in of *heermanni* is gradual, and assumes dominance at the bases of the steep hills (Pl. II, upper). Where *heermanni* is first encountered, hillward from Site 2, the other species of small mammals, *Peromyscus*, *Perognathus*, and *Onychomys*, begin to be encountered in far greater numbers than ever before, in fact *P. inornatus* is found only in these transitional sites. *D. nitratoides* may be found even to the hill bases, but seldom on the hills. As Site 5 is reached the smaller rodents again become rare.

Thus, it appears that where this transitional area between Sites 2 and 5 occurs, the two brush-adapted kangaroo rats are found together in about equal numbers. It appears also that other small rodents are able to maintain themselves in this type of habitat, but do not seem to occur in the same numbers as the *Dipodomys*. It might then be interpreted that where no single species of kangaroo rat is dominant, other factors such as vegetation and rock outcrops being favorable, other small mammals may become established.

Site 4.—This site is more rolling than any of the previous ones, usually has steeper pitches, a great deal of variation in plant cover, a number of rock outcrops, and some narrow watercourses. Most of this site is adjacent to the steeply rising hills so there is a constant variation between fairly level land and steep slopes. Thus, there are changes in topography, air currents, and moisture with the consequent variation in plant cover. This "site" then may, in truth, be made up of a number of microhabitats where only one animal would occur under a single shrub or on a small change of slope. Scattered through this area also are a number of small plots, with all of the characteristics of Sites 1, 2, and 5 that are large enough to have a small population of the characteristic rodents. Thus Site 4 is also subjected to these adjacent influences. The same annuals and perennials are present with *Ephedra* reaching densities of 14–23 shrubs per acre.

Trapping records within this site are as follows: March 4, 1943, 1 *D. heermanni* and 2 *P. maniculatus*; December 27, 1945, 1 *P. maniculatus*; March 15, 1947, 3 *D. heermanni*; December 13, 1947, 2 *D. nitratoides* and 1 *O. torridus*; October 9, 1948, 1 *D. nitratoides* and 1 *O. torridus*; October 15, 1949, 1 *D. nitratoides* and 4 *O. torridus*; December 4, 1949, 1 *D. ingens*; March 11, 1950, 2 *D. heermanni*, 1 *D. nitratoides*, and 2 *D. ingens*; April 22, 1950, 2 *D. heermanni*, 2 *D. ingens*, 1 *P. inornatus*; and 1 *O. torridus*; April 23, 1950, 4 *D. heermanni*, 2 *D. ingens*, and 2 *D. nitratoides*.

This site appears to be an area where no species is particularly dominant. Within one-half acre there may be brush, rocks, slopes, and flats, and 25 traps spread through such a half-acre may take any of the above combinations. All of the known rodents of the area, except *Citellus beecheyi*, are found here along with *Lepus californicus* and *Sylvilagus auduboni*. Thus the variable habitat may

either keep any one species from becoming dominant, or it may provide the small niches necessary for all, and, although *ingens* is well established and dominant at its open end of the transect, *nitratoides* equally so on its brushy ridges, and *heermanni* almost alone on its steep brushy slopes, no one exerts a great deal of influence here. Here, as in Site 3, but lacking the influence of *ingens* there, the other small species are well established, though still not as numerous as the *Dipodomys*. This finding is similar to that of Culbertson in that he also found that where the habitat was most constant the kangaroo rats were almost solitary, but when brush was added, the other small rodents were able to establish themselves. *Peromyscus*, *Perognathus*, and *Onychomys* are found here, as in Site 3, in numbers. In Site 3 they became established in opposition to *D. heermanni* and *D. nitratoides*, while here the addition of *D. ingens* has not discouraged that establishment. All three species seem to be tied to this brushy, dissected, rocky, incompletely dominated habitat.

Site 5.—This site is located on slopes of 20 per cent or more. There are rock outcrops, sometimes occupying 30 per cent of a half-acre plot. The *Ephedra* is scattered over the plot in varying densities with *Stenotopsis* taking up much of the area between, particularly on the northwest-facing slopes; on the southwest-facing slopes *Eriogonum* replaces in part the latter shrub. East slopes usually have only *Ephedra* and annuals on them. *Poa* is still present, and *Bromus* is in far greater abundance than *Erodium*. This site is found only at the southern end of the study area (Pl. II, upper).

Trapping records within this site are as follows: November 30, 1946, 2 *D. heermanni* and 1 *O. torridus*; February 19, 1950, 1 *D. heermanni*; April 4, 1950, 10 *D. heermanni* and 1 *D. nitratoides* (south slope); April 22, 1950, 4 *D. heermanni*; April 23, 1950, 2 *D. heermanni* and 1 *P. inornatus*.

There is a higher population on the south-tending slopes, but definitely these steep, heavily brushed sites are the metropolis of the Tulare kangaroo rat in this region. The additional species were all taken along the lower edge of the site where it blends with Site 4. Cottontails are quite numerous in this habitat, and occasional jackrabbits may be seen, but the ground squirrels are absent. It appears that this one species is (1) either dominant under these conditions; (2) that it is more adaptable and upon being crowded out of the seemingly more favorable situations by the other species it is able to maintain itself here; or (3) that the other species are so specialized, as most certainly seems to be the case with *ingens*, that they are incapable of invading this area.

Site 6.—This site is approximately 500 feet above the plain below and is on a slope that varies from 6 to 17 per cent. The gentler slope faces the southwest and the steeper one almost due south. Here are 10–14 *Ephedra* plants per acre, with *Stenotopsis* and *Eriogonum* well represented in between. Here is found the *Yucca* in fairly heavy concentrations also. Rock outcrops are common on these slopes—much more so than on the north-facing ones. The annuals are the same as before. Plate II, lower shows the more characteristic features of the site. As can be seen by comparing with Plate II, upper, this site is very similar to Site 5, except for the elevation and *Yucca*.

Trapping records within this site are as follows: October 9, 1948, 1 *D. heermanni*, 2 *P. californicus*, and 2 *N. lepida*; November 15, 1948, 1 *D. heermanni*, 1 *P. californicus*, and 1 *P. maniculatus*; November 19, 1949, 12 *D. heermanni*, 1 *P. californicus*, 6 *P. maniculatus*, and 3 *O. torridus* (this set and next, 120 traps); December 5, 1949, 6 *D. heermanni*, 1 *P. californicus*, and 1 *O. torridus*; April 3, 1950, 7 *D. heermanni*, 3 *N. lepida*, and 2 *O. torridus*.

This fairly steep, heavily brushed slope is still more thickly populated with *D. heermanni* than with any other species, but a change in habitat, as denoted by the presence of *Yucca*, has allowed other small rodents to become established. The difference between the two sites is not only one of altitude, however, as both *lepida* and *californicus* have been taken at the junction of Silver and Panoche Creeks, at an elevation of between 600 and 700 feet. The latter location is one of extreme variation similar to Site 4. This site again appears to be a transitional one, if a greater number of species indicates a mixed habitat, but it is different from the variable sites, at lower elevation, as already discussed above. The slopes above this site lack *Yucca*, as can be seen in the background in Plate II, lower, but on the basis of one 50-trap set and observation, *heermanni* is still present, but *Onychomys* and *Peromyscus* are well established. Significantly, no other species of *Dipodomys* has been caught in or near this site.

It appears that if this is a transitional site, careful study of still new conditions of habitat might result in the finding of yet another change in kangaroo rat habitat—possibly the passing of *Dipodomys* out of the picture entirely, or the advent of yet another species.

Conclusions.—The giant kangaroo rat is dominant, within its range, where the area lacks brush and sharp physiographic variations. This is the same conclusion as that reached by Grinnell and by Shaw. Where there are variations from this habitat, the giant kangaroo rat may still be present, in suitable spots, but is no longer dominant, except within its precinct.

The short-nosed kangaroo rat is found on gentle slopes and rolling low hilltops where brushy growth is present, but does not venture far out of this habitat. Within this habitat this *Dipodomys* is apparently dominant over either of the other two, even though it is the smallest of the three. A related subspecies is found in open land, where *ingens* is not present.

The Tulare kangaroo rat is pushed out of the plains which it may occupy when *ingens* is not present, and seems unable to compete with *nitratoides* on the brushy, rolling areas, even though it is found with a subspecies of that species in another habitat. It is adaptable enough to very adequately use the steep, brushy, rocky hillsides, which neither of the other two seems able to do. Tappe has already indicated this adaptability in his study of this *Diopdomys*.

There are areas of transition, here represented by either rolling ridges or pitches, where the habitat is variable and adjacent sites bring influences to bear. Here the other species of small rodents are most numerous and seem to be best established. These species are seldom found in the metropolis of any of the kangaroo rats.

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BEHAVIOR PATTERNS OF THE LABORATORY MOUSE UNDER AUDITORY STRESS

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There has been a rather large amount of work done on running fits and seizures in rats, following the original report by Maier (1939), and various mechanisms have been proposed to explain these types of "abnormal" behavior. Much less has been done on mice, however. The fact that seizures occur in mice was first reported by Dice (1935) and later studied by Watson (1939) for the deer mouse, *Peromyscus*. Recently, Chance and Yaxley (1949) have analyzed the behavior sequences in this genus during running fits and seizures.

In laboratory stocks of the house mouse the occurrence of audiogenic seizures was first reported in a preliminary way by Mirsky *et al.* (1943) and was later studied by Hall (1947). The behavior, in this case, was induced by subjecting a mouse in a metal washtub to the sound of an electric bell fastened to the tub. Later, Ginsburg *et al.* (1947, 1949, 1950), Fuller (1950), and Vicari (1947, 1948*a* and *b*, 1949, 1950) published brief abstracts of work using various inbred strains of the house mouse in this type of apparatus. Witt and Hall (1949), in a genetic study of seizures in two strains of mice, reported that mice of the *dba* strain were seizure-susceptible while *C-57* strain mice were seizure-resistant. Study of crosses between the two strains led them to conclude that the occurrence of seizures at 30 days of age was brought about by a single dominant gene, present in the *dba*, with the recessive allele homozygous in the *C-57*'s.

A few deficiencies in all these papers on house mice led to the present study. First, there has not been an adequate description of the pre-running behavior of the mice or of the running fits and seizures themselves, comparable with that of Chance and Yaxley (1949) for *Peromyscus*. The present paper attempts a detailed description of the behavior of mice subjected to relatively intense auditory stimulation. Second, the stimuli used by the previous workers were complex and nearly unreproducible. Not only were the mice in a tub to which a bell was attached subjected to sound, they were also receiving vibrations through the feet. If *reproducible* results are to be obtained, it is vital that the frequencies and intensities of sound used in studies of seizures in rodents be known exactly. Our

first problem, therefore, was the designing of a piece of apparatus which would allow control of the stimuli used for the induction of seizures. Third, except for the reports (only abstracts) of Ginsburg *et al.*, Fuller, and Vicari, the tests on house mice have been made over a very limited time of the life—30–40 days of age. The time of treatment should be extended into the earlier days of life to discover the age at which seizures first appear, as well as into the later life to discover the time when seizures cease, if at all. Only the first part of this problem, extending into earlier days of life, is reported here, for, besides making a study of the occurrence and pattern of seizures, we also had afoot an attempt to produce mice of known susceptibility to running fits, and kept our mice, after 50 days of age, for breeding. Fourth, except for the use of a few inbred strains of mice no attempt has been made to standardize stocks for studies of seizures. It is important, if comparative results are to be obtained in studies on seizures, that animals of known genetic background *with respect to seizures* be used. This phase of our work is still in progress.

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MATERIALS AND METHODS

Animals used and general methods of maintenance.—Individuals of three strains of mice were used in this study—mongrel "Swiss" Albino, obtained from a commercial animal dealer; *dba* (Subline 1), obtained from the Jackson Memorial Laboratory, Bar Harbor, Maine; and *C-57* black (Subline 6), likewise obtained from the Jackson Memorial Laboratory. These animals were paired immediately upon receipt, when they were all about 40–50 days of age, and their offspring were used in the experiments.

The animals were kept in a standard mouse cage made of galvanized iron, with solid bottom, fitted with a lid of $\frac{1}{4}$-inch-mesh hardware cloth. The bottom of the cage was filled to a depth of about one inch with sawdust to absorb wastes. These were kept in a laboratory in which temperature, humidity, and light were allowed to vary with the outside early summer conditions. Food and water were constantly available. The food was a commercial mouse diet. Since it has been shown that nutritional deficiencies may affect the incidence of seizures in rats, a preliminary study of the possible effects of this diet on seizures in mice was made by supplementing the diet of half of the *C-57* animals with dog biscuit. So far as could be determined, the animals were free from diseases or parasites, with the possible exception of mites, which occur widely in small numbers on laboratory mice.

The albino mice produced significantly larger litters than the other two strains, and, because of better parental care, brought through more young to testing age. The *dba* strain had the smallest litters and brought through to testing age only about two-thirds of the mice born. The *C-57* mice had litters of intermediate

size and, with excellent parental care, brought through almost all the young to testing age. The albinos and *C-57*'s are, therefore, preferable to *dba*'s as experimental animals, because of the larger numbers for testing afforded per breeding pair.

The mice were handled as little as possible between and during the tests. It seems almost certain that the amount and nature of handling would affect the induction of seizures in the mice, and an effort was made, therefore, to duplicate the handling procedure for all the mice tested. Between tests, the animals were generally undisturbed. The mouse cages and water bottles were cleaned twice each week, care being taken to disturb the mice as little as possible.

For purposes of identification, the mice were marked with an alcoholic solution of picric acid, using marks on different parts of the body to represent the numbers of the animals. In general, the male mice were left with the females with litters, and both mice took care of the young. The young were tested from 15–50 days of age, and they were removed from their parents at 30 days of age. At this age, almost all of the mice had been weaned.

Apparatus.—The sound source used in these experiments was a Western Electric Microphone (Type 633-A), actuated by a Hewlett-Packard audio-oscillator (Type 200-A), with a Raytheon pulse transformer (Type WX-5137) in series with the microphone to match the impedance of the external and internal circuits. The sound was turned off and on by a switch in the external circuit.

For testing, the mice were imprisoned in a cage, 15 cm. long, 10 cm. high, and 10 cm. wide, made of $\frac{1}{4}$-inch-mesh hardware cloth. This cage was placed so that the microphone, which was on a platform 2.5 cm. above the level of the floor of the cage, was 5 cm. from the cage, sending a sound beam down the long axis of the cage.

In the first experiments, two frequencies were used: 10 kc./sec. and 20 kc./sec., the first being sonic, the second ultra-sonic, so far as man is concerned. Both are sonic for mice, but there were fewer seizures at 20 kc./sec. than at 10 kc./sec. Both of these were delivered to the microphone at the maximum intensity of the oscillator. As a result of the response characteristics of the microphone, however, the actual intensity of sound produced at 20 kc./sec. was 10 to 20 db. below that produced at 10 kc./sec. It soon became apparent that the lower intensity at the higher frequency—for which no remedy was found with the present apparatus—was probably the cause of the difference in incidence of seizures between the two frequencies. Since this was not intended to be a study of frequency and intensity variables in the seizure pattern, the use of the higher frequency was discontinued. In actual numbers, 10 Albinos out of a total of 37 used and 20 *dba*'s out of a total of 40 used were the only mice tested at 20 kc./sec.

In a preliminary study on the effect of frequency on the evocation of seizures in *dba* mice, McGrael (1949) has shown that the maximum number of seizures is induced at 8–12 kc./sec., when he tested mice at 2–20 kc./sec. in 2 kc. steps, all at 102 db. sound pressure. For this reason, 10 kc./sec. was selected. In view of his results, it may be that the much smaller number of seizures induced at 20 kc./sec. may have been due to the frequency, but we cannot conclude definitely on this point.

The sound pressures inside the testing cage were measured by means of a calibrated system consisting of a Western Electric 640-AA microphone, Sanborn preamplifier, and Ballantine Model 220 voltmeter. This was accurate to within ±0.5 db. The average sound pressure (in db. re 10^{-16} watts/sq. cm.) in the cage was 110 db.; the range was from 120 db. nearest the transducer to 105 db. at the far corner of the cage.

Using a metal washtub arranged like that used in the previously reported work—so far as such an arrangement can be duplicated—the sound levels in the tub were found to be 102±2 db. at the periphery and 95±2 db. at the center. Thus, so far as sound pressure itself is concerned, the total sound pressure in our apparatus compares favorably with that in the tub.

To minimize discomfort to the experimenter, the cage and microphone were enclosed in a small anechoic chamber (61 cm. long, 31 cm. wide, and 31 cm. high, outside dimensions) made of plywood. This was lined with two layers of non-absorbent cotton covered with a layer of cheese cloth. The inside dimensions of this chamber were 58 x 23 x 20 cm. Access to the chamber was through a door at one end. The microphone was inserted through a small door in the end of the box opposite the large door. The cage was placed in the middle of the anechoic chamber (Pl. I). Directly above the cage there was a window (10 x 10 cm.) covered with a layer of celluloid, beneath which the cotton lining of the chamber was partly removed. Through this window, light from a small lamp was admitted. Another window in the side of the box (18 x 18 cm.), made of two layers of celluloid with an air space between, afforded the experimenter a clear view of the cage.

Experimental procedures.—The routine followed in testing a mouse for susceptibility to seizures was as follows. The mouse was placed in the testing cage and the cage placed in the anechoic chamber. The mouse was given a period of about a half minute to accustom itself to the cage, and its reactions during the pre-testing period were recorded. The sound was then turned on. The immediate reaction of the mouse to the sound was observed, and the behavior of the mouse during the treatment was followed continuously, timing by means of a stop watch, and recorded. If the animal did not have a seizure, the sound was kept on for 90 seconds. If the animal did have a seizure, the sound was turned off just as soon as the mouse started to run. The latter procedure saved the mice for further testing and for breeding. The seizures ranged in severity from merely stopping in some unusual position to complete convulsions, followed by death. In all cases in which the animal recovered following a seizure the time for recovery was observed and recorded. The animal was designated as recovered when it had returned to normal positions or movements in the cage. Following the test, the mouse was returned to the maintenance cage.

Each mouse was tested twice per day during the week, with only one test on Saturday and usually none on Sunday. If, however, the animal was at such an age that it was suspected that its first seizure would occur on Sunday, it was tested. The tests were made in the morning and in the afternoon. There were about four hours between morning and afternoon tests and, thus, about 20 hours between the afternoon test of one day and the morning test of the day following.

Records of the actions of the mice were taken in an abbreviated code, allowing the observer to record the events as they happened. Preliminary experimentation revealed that there were certain typical behavior patterns before and during testing, and single letter symbols for these were used. Where unusual behavior patterns turned up, they were easily noted and inserted in the records in the form of notes. The record sheets were lined to represent 5-second intervals over the testing period, and usually these spaces sufficed.

The following numbers of mice and tests were made in this study: Albino—offspring from five pairs of parents, totalling 37 (17♂♂ and 20♀♀) individuals in 1950 tests, with 448 seizures; *dba*'s—offspring from nine pairs of parents, totalling 40 (20♂♂ and 20♀♀) individuals, in 1365 tests, with 307 seizures; *C-57*'s—offspring from six pairs of parents, totalling 53 (24♂♂ and 29♀♀) individuals, in 2695 tests, with 466 seizures. Thus a total of 130 mice (61♂♂ and 69♀♀) was used in 6010 tests, with 1221 seizures.

RESULTS

Behavior patterns of mice before and during sound treatment.—The pre-treatment behavior of a mouse in the treatment cage depended chiefly upon its age and its previous experiences in the cage. Naturally, there were wide individual variations in behavior patterns among the mice, but these were all generally classifiable under certain typical types of behavior.

If the mouse were young—between 15 and 18 days of age—the most usual pre-treatment behavior was either a simple exploration of or a quiet resting position in the cage. The quiet state was usually assumed in a corner, with the animal sitting relaxed, often with the eyes closed. Exploration of the cage was of various types. Most of the animals moved about without making any effort to escape. A few moved about quietly, stopping occasionally to poke the nose out through the sides of the cage or even to bite at it. A few climbed the sides of the cage, or alternated climbing with moving about on the floor. Climbing, too, was occasionally accompanied by attempts to escape, though this type of behavior was very rare. Some mice, instead of either sitting quietly or moving about, would clean the fur in the normal fashion, using the forepaws for facial cleaning and the tongue for the body. In general, the behavior was exactly like that observed whenever young mice are removed from their home cage and placed in a strange situation.

If the mice were older—18–50 days of age—the pattern was a little different. Generally they exhibited active movements about the cage, some mice alternating these movements with climbing of the sides, and some cleaning normally, all usually carried out in an unhurried fashion. If, however, the mouse had a long record of previous seizures in the cage, the behavior was usually markedly altered. In this case, the mouse either moved or ran about vigorously, trying to escape, or cringed in a corner, as if expecting something to happen. If the last sounds anthropomorphic, it is not meant to be, it merely describes most accurately the tense, expectant, crouching attitude of the mouse. The latter pattern was typical of mice which had had violent seizures, though some of them

also exhibited the active type of behavior. There would seem to be good evidence that the mice learned to fear the experimental situation, after being subjected to repeated seizures.

When the sound was turned on, the immediate reaction was a startle. This varied in intensity from a mere drawing in of the head, as if the mouse had been tapped on the snout, to a powerful jump which lifted the mouse completely off the floor of the cage. The former type of behavior was characteristic of very

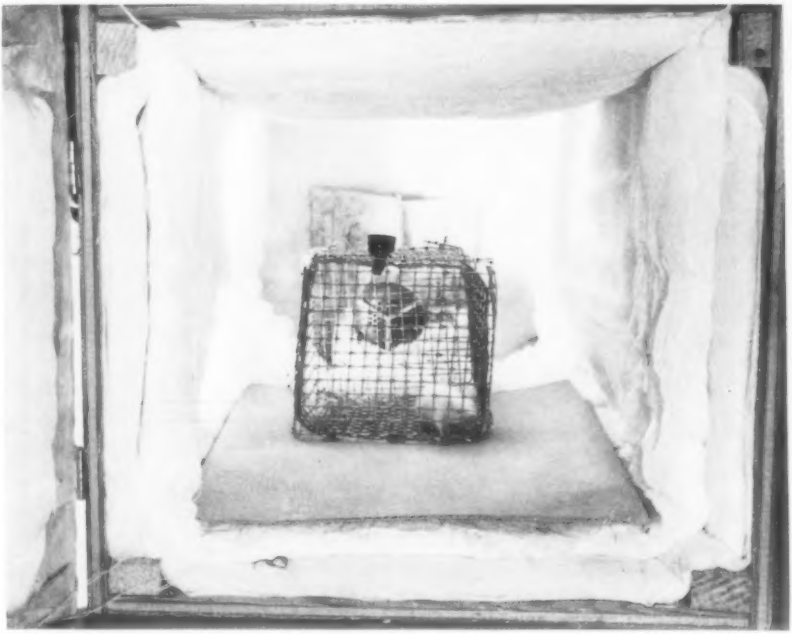

PLATE I

Interior of anechoic chamber containing the testing cage and microphone

young mice or of older mice which no longer were having seizures. A very few of the older mice, with long records of non-seizure, seemed to pay little or no attention to the sound when it was turned on. These were not deaf, however, for they did respond well to sounds outside of the test situation, but they were usually so busy moving or climbing about that the slight jerk which may have occurred could not be seen.

Up to the occurrence of a seizure, the behavior patterns while the sound was on were modifications of the pre-testing patterns. In very young animals the quiet position was maintained. In animals over 16 days of age this quiet attitude became a cringe. This was probably the most characteristic reaction to the sound. The cringe in younger mice was characterized by drawing together of the body,

PLATE II

UPPER: Full convulsion which usually ends in death. Note spread digits, stiffened tail, closed eyes, ears laid down, crossed front legs, and vigorously extended hind legs
LOWER: Mouse during running fit. Photo speed = 1/1000 sec.

erection of the hairs, laying back of the ears, and usually closing of the eyes. In older animals, a typical cringe consisted of drawing in of the body, erection of the fur, and laying back of the ears; the eyes usually were left open and often seemed to bulge. The cringe varied in severity from a crouch which was almost like the quiet position to a very deep cringe; the mouse very excited and ready to dash off at any moment. The depth of the cringe depended chiefly on the seizure susceptibility of the animal. If the animal had not had seizures for some time, it was likely to be mild; if the animal had had repeated seizures, the cringe was very deep. The severity of the cringe was a sign of the possible occurrence of a seizure—a very excited cringe usually foretold a seizure.

The quiet normal moving of the mouse about the cage was usually changed during the period of sound treatment into a more active, restless type of movement, almost invariably associated with vigorous attempts to escape by thrusting the nose through the cage bars. In many mice there was a continuous alternation of this active behavior with the cringe. A further modification of the quiet moving about was a very rapid movement, in some cases becoming an actual run, usually accompanied by vigorous attempts at escape. Another pattern was what appeared to be an almost simultaneous cringe and motion, in which the animal moved sidewise in short jerky steps. This we designated as a moving cringe and it often preceded a seizure. The over-all picture in these sequences was the alteration of a quiet coordinated pattern of exploratory movement into a vigorous and occasionally nearly uncoordinated pattern of escape from the cage.

The climbing pattern seen in the pre-testing period was also modified into a more rapid and vigorous climbing, usually accompanied by attempts to escape. There was considerably more climbing among the mice after the sound was turned on than before sound treatment, all the mice exhibited this type of behavior at some time during the testing. Climbing during sound treatment varied from more or less quiet climbing, such as is seen in normal animals, to a furious, almost uncoordinated climbing alternating with running.

The cleaning pattern seen in the pre-testing period was also modified during the testing period. Cleaning was not a common pre-testing pattern, but it was very common during the testing period. It varied from true cleaning, just as a normal mouse would perform the act, often, however, more vigorous than the normal pattern, to abortive attempts at cleaning, consisting merely of passes at the nose. The term, tic, as used by Chance and Yaxley (1949) undoubtedly applies here. The activity was a mere incomplete part of the normal behavior sequence. It is worth noting that animals which exhibited mere abortive attempts at cleaning often were those which later had seizures, while animals which went about the cleaning in a business-like fashion were usually animals which would not have a seizure during that testing period.

All of the previous patterns were exhibited both by animals which had seizures and by those which did not. It remains to describe the sequence of behavior observed during the seizure.

The first phase of the seizure in mice is the running fit. This started from one

of the behavior types described above, most usually from a deep cringe (57 per cent of the times in all strains) or from a very rapid moving or climbing pattern (40 per cent of the times), most rarely from a cleaning pattern (1 per cent of the times). In this running fit, the animal dashes wildly about the cage, on the floor and up the sides, often leaping from side to side. It would be incorrect to call this uncoordinated, for the mice do not run headlong into the sides of the cage. They seem well able to seize the walls and to climb them when they come to them, rather than simply running into them. Plate II, lower, shows a mouse in a running fit. The photo was taken at 1/1000 of a second, a speed which was necessary to stop the motion. During the run, the tail is held very stiff, the eyes are wide open, and the animal moves violently. The severity of the running fit usually presages the severity of the sequel. In our work we stopped the sound at the start of the running phase of the seizure. It was hoped thus to have fewer mice die in the seizures, and this proved to be well founded for 75 per cent of the mice lived even though they were tested twice per day for 36 days. Under these conditions, the duration of the running phase was two to fifteen seconds, most usually about five seconds.

The severity of the fits which follow the running depends primarily on the individual and secondarily on the rapidity with which the sound is turned off once the mouse has started to run. In a full seizure, resulting in death, the mouse rolls over on the side and the feet kick uncoordinatedly. This phase continues for a short time, sometimes only a second, and then the mouse draws up the hind legs and thrusts them out vigorously to the rear, extending them as far as possible, with the toes widely spread, while at the same time the front legs are drawn together over the chest, the tail is extended stiffly behind, the eyes are tightly closed, and the ears are folded tightly against the head (Pl. II, upper). This position is held for about 10 seconds, then the animal relaxes, the ears return to the normal erect position, and the animal is dead.

Incomplete seizures were most usual in our work. These range from rolling over in the uncoordinated pattern preceding stiffening in the full seizure to merely stopping the run in a modified cringe position. Watson (1939), for *Peromyscus*, designated the incomplete seizure types as a stupor, in which the animal looks and acts as if it were recovering from a full seizure, but has not had one, and a semi-stupor, in which the animal lies as in a stupor, but is capable of moving about. Recovery from these two types is, as might be expected, relatively easily accomplished. Recovery from the type of seizure in which the animal rolls about in an uncoordinated fashion is generally rather slow. We were able to revive a few of the animals which were in a full seizure, provided they had not relaxed after the stiffening, by swinging them about by the tail. Since the mice were wanted for breeding, an effort was made to prevent full seizures, or, if they occurred, to prevent death by this method of "artificial resuscitation."

Comparing the behavior patterns of the house mouse under auditory stress with those of *Peromyscus*, as described by Watson (1939) and by Chance and Yaxley (1949), many similarities can be noted. The behavior during the induction period is strikingly similar. The differences are mainly in the seizure itself. *Peromyscus* runs uncoordinatedly in the first phase, bumping into obstacles, so

that it is necessary to protect the individuals against injury. The house mouse does not run uncoordinatedly. Until it starts to roll about in the second phase of the seizure, the animal avoids obstacles and climbs the cage well. We have

TABLE 1.—*Numbers of seizures and deaths during seizures for mice of the strains tested from 15 to 50 days of age. (No. tested = numbers of mice which were tested each day; No. seiz. = numbers of mice which underwent seizures in tests; No. dying = numbers of mice which died in seizures each day)*

AGE IN DAYS	ALBINO			DBA			C-57		
	No. tested	No. seiz.	No. dying	No. tested	No. seiz.	No. dying	No. tested	No. seiz.	No. dying
15	37	0		37	0		46	0	
16	37	1		35	3	1	39	0	
17	37	3		36	15	4	53	8	
18	37	7		35	14	3	53	10	
19	37	13		32	20	3	37	12	
20	36	18	1	25	16	2	46	23	
21	36	23	1	25	19	2	50	24	
22	35	20		25	22	3	40	21	
23	35	24	1	21	11	2	39	21	
24	34	24		20	10		53	32	
25	27	15		19	11	1	53	21	
26	34	18		19	11		37	11	
27	29	15	1	19	12	1	46	19	1
28	33	15		17	11	1	49	13	
29	29	13		16	8		39	12	
30	32	12		16	5		38	12	
31	32	11		15	6		52	15	
32	31	13		17	3		52	11	
33	31	10		17	6		37	7	
34	20	8	1	15	3		45	9	
35	28	7		17	6		48	11	
36	26	6	2	17	3		38	6	
37	25	6		16	4		37	8	1
38	25	5		17	6		50	5	
39	19	0		17	5		50	4	
40	21	5		13	4		29	2	
41	13	4		15	3		30	2	
42	25	2		15	2		33	4	
43	22	4		16	0		30	1	
44	25	3		17	1		30	0	
45	25	3		13	2		36	0	
46	19	0		17	3		36	0	
47	21	4		13	1		22	0	
48	13	5		12	0		30	0	
49	25	2		15	1		33	0	
50	22	3		16	0		30	0	

not had our animals injured during this phase of the seizures. *Peromyscus* has a type of seizure which is designated as a "bouncing" seizure. We have not observed this form of behavior in the mice we have tested.

Following recovery from a seizure, the animals seemed perfectly normal. The

time for recovery depended on the severity of seizure, ranging from 10 to 200 seconds with the average about 30–50 seconds. If the animal had been merely in a semi-stupor or a stupor, or had had a rather mild second phase convulsion (clonic type), recovery was rapid and the animal shortly moved about or cleaned normally. If the animal had had a severe second phase (clonic) convulsion or recovered from a full (tonic) seizure, recovery was usually slow and the animal ordinarily started moving about in circles with the legs extended, this activity changed in some seconds into normal movement. The average recovery times for the mice were: Albinos, 36 seconds; *dba*, 35 seconds; *C-57*, 24 seconds. The difference between the recovery times for the first two and the latter strain is

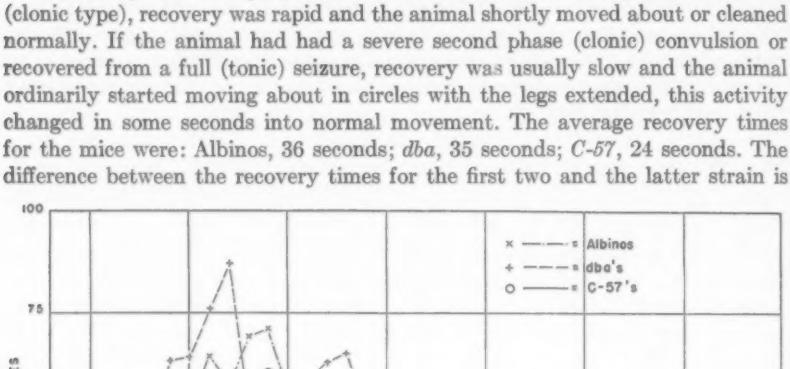

FIG. 1.—Seizure susceptibility of mice as a function of age. Records for Albinos for days no. 39, 41, 46, and 48 are omitted, because on these days, purely accidentally, all the animals which were having seizures or most which were not having seizures were not tested.

significant. In the post-seizure period the house mouse differs from *Peromyscus* in not exhibiting saltation or catalepsy.

There were very few strain differences in behavior patterns during the tests. In general, the *dba* mice seemed more nervous and jumpy and were definitely more prone to undergo full seizures, even when the sound was turned off at the beginning of the running phase, than the other strains. The *C-57* mice seemed probably more prone to occupy themselves with cleaning and with business-like movements while in the cage than did the other two strains. Other than that, the behavior patterns were identical. Counts of defecations and urinations, as recorded by Hall (1947), gave so little of value that they were discontinued after a short time. These counts might be significant if the mice were handled only once, but with repeated handling the numbers of defecations and urinations become too small to mean much.

Seizure susceptibilities as affected by age, sex and strain of mice.—The records

of the three strains of mice used are presented in Table 1. In this table, the two tests on each day are recorded as a unit; if the mouse had a seizure at either or both of these tests it is recorded as positive for that day. Thus, the number tested refers to mice tested, not to the number of tests, since on most of the days there were two tests per mouse, and the number of seizures refers to the number of mice which had either one or two seizures on a given day. Most of the mice during the period of their maximum seizure susceptibility had seizures at both testing periods, but during a period of low susceptibility had only one seizure per day.

The percentage of seizures (i.e., number of animals having a seizure divided by number of mice tested $\times$ 100) is plotted against age in days in Figure 1.

From these data it is obvious that there are few differences in seizure susceptibility among the three strains over the age range tested. The *dba*'s are most susceptible, reaching a higher percentage of seizures than the other two strains. The Albinos are intermediate, and the *C-57*'s least susceptible, but the differences are not great. As a matter of fact the differences between individuals of the same strain—nay, of the same litter—were greater than those between the strains. This is well illustrated in Table 2. This presents a selection of seizure records for mice from the three strains. Those mice which have the same first number in the number series are siblings. Thus, in the *C-57*'s, all the examples are from the same parents. These range in seizure susceptibility from one seizure (30-1-4) to 22 seizures (30-2-7) in the same number of tests. Similar wide variation can be shown in the other two strains. Of particular interest—in view of the limited testing periods employed in previous studies (Hall, 1947; Witt and Hall, 1949)— are records such as those of no. 1-1-1, 8-1-10, 6-1-2, 30-1-3, and 30-1-5. These show periods of seizure susceptibility alternating with periods of non-susceptibility. If animal no. 8-1-10, for instance, were tested only from 30–34 days of age it would be classified as non-susceptible. Yet this animal has a high record in the 18–29-day period and later, at 36 days of age, again became susceptible and died. The seizure-age patterns which could be called most typical, of those shown in Table 2, are: for Albinos, 2-1-5; for *dba*'s, 3-1-4 (including death), and for *C-57*'s, 30-1-1.

There are striking inter-strain differences in the death rates in seizures. Even taking into account the fact that these death rates were influenced by the speed with which the experimenter turned off the sound, it seems reasonable to assume that the number dying in these tests would be a reflection of the basic susceptibility to death, since all the mice were tested similarly. Obviously the *dba*'s are most likely to die, the Albinos are intermediate in this respect, and the *C-57*'s are least susceptible. A further fact, not presented in the table, is that males seem more susceptible to death in seizure than do females. Thus, in the *dba*'s, of the 23 animals that died, 14 were males. The two *C-57*'s which died were both males. Of the seven Albinos that died, three were males and four were females, but, since more females than males were tested, these are essentially equal. Thus, this work suggests that males are more fragile in seizures than are females. This was, interestingly enough, the only possible sex difference observed in this work.

TABLE 2.—*Selected records of seizures in mice.* (s = *seizure on day indicated;* nt = *not tested;* DS = *died in seizure*)

| MOUSE NO. | SEX | AGE IN DAYS | | |

The earliest age at which a seizure appeared in the Albino mice was 16 days, the latest (excluding two mice which had no seizures at all during the tests) was 24 days. For *dba*'s the earliest age for the first seizure was also 16 days, the latest 22 days. For *C-57*'s, the earliest age was 17 days, the latest 37 days, with one animal without a seizure. The mean ages of first seizures and standard errors thereof for the three strains are: Albino, 20.0±0.5 days; *dba*'s, 18.5±0.3 days; *C-57*'s, 20.5±0.7 days. Thus, it would appear that the *dba*'s have a slightly earlier average age of appearance of seizures, but the difference is not significant.

With respect to the latent periods of seizures, that is, the time elapsing from the turning on of the sound to the appearance of the running fit, no clear-cut sex or strain differences were established. Thus, for Albinos the mean latent period is 35±1.7 sec. for males and 31±1.0 sec. for females. For *dba*'s the mean latent periods are 34±1.3 sec. for males and 32±1.7 sec. for females. For *C-57*'s the mean latent periods are 30±1.2 for males and 32±1.3 for females. For all three strains the range of times for latent periods was from 5 to 90 seconds, with a distribution skewed toward the lower time limits. In view of the large standard errors and the skew of the curves, the differences between males and females are not significant, but further work is needed to test this.

There seemed to be an interesting relationship between the latent periods of seizures and the seizure pattern of the animals. Thus, in Albinos the mean latent period of the first two seizures was 38 seconds, of the middle three seizures in a continuous group of more than six, 29 seconds, and of the last seizure, 49 seconds. Putting the data into words, the mice which were having seizures regularly had shorter latent periods during the period of maximum seizure incidence than at the start or the end of the series. This has been reported previously for seizures in rats by Morgan (1941). In *dba*'s a nearly similar phenomenon was observed. The mean latent period of the first seizures was 47 sec., the mean latent period of the middle three seizures, 33 sec., and of the last seizures, 31 sec. Here, there is no extension of the latent period at the end, the animals seeming to have seizures as quickly at the end of the seizure-susceptible period as at the middle. In *C-57*'s the mean latent period of the first seizure was 38 sec., of the middle three, 32 sec., and of the last, 29 sec. In this respect the *C-57*'s resemble the *dba*'s more than they do the Albinos.

Summarizing the data, the following may be stated: (1) there are few observable differences in basic behavior patterns of mice of the three strains tested either before or during the testing; (2) the period of maximum seizure susceptibility for the three strains is between 20 and 25 days of age; following 30 days of age the susceptibility declines markedly; (3) the order of susceptibility over most of the range tested is *dba*'s most susceptible, *C-57*'s least, and Albinos intermediate, and this is also the order of appearance of seizures with respect to age; (4) *dba*'s are more susceptible to death in seizure than are Albinos or *C-57*'s; (5) there are no significant differences in the latent preiods of seizure, but the *C-57*'s recover more rapidly from seizures than do the other two strains; (6) there are great differences among individuals, even from the same litter, in seizure incidence.

The experiment on supplementation of the basic mouse diet with dog-biscuit showed that the additional food did not affect the seizure incidence. In those *C-57* individuals which received only the mouse diet, there were 191 seizure-days in 847 days of testing (22.6 per cent). In animals receiving the supplement, there were 133 seizure-days in 619 days of testing (21.5 per cent). Either the mouse diet itself is adequate nutritionally, so far as the seizure pattern can detect, or, at least, the addition of dog-biscuit is ineffective. Preliminary tests in which mice were given a wide variety of food supplements showed that these mice were just as susceptible to seizures as were those not receiving supplements. It seems reasonable, therefore, to believe that dietary deficiencies are not the factor bringing about seizures. This does not mean that dietary deficiencies may not seriously affect seizure incidence, but it seems almost certain that mice, even though receiving a perfect diet, could still be seizure-susceptible.

DISCUSSION

This report is descriptive and not meant to suggest possible mechanisms for the seizure pattern in mice. No attempt will, therefore, be made to compare these results with those obtained on rats.

Certain points should be noted, however. This work does not seem to confirm some of the work of Hall (1947) and of Vicari (1947, 1948*a*) on mice of the same strains. The differences are probably due to the differences in testing procedure and apparatus. McGrael (1949), for instance, has shown that a much higher percentage of seizures can be induced in mice in a tub to which an electric bell is attached than can be induced with pure tones. These results show either that non-sonic stimuli in the tub are of great importance, or that complex tones are more effective than is a simple 10 kc. note. Since frequency, modulation, or rhythm of the sound or vibrations through the substrate might have an influence on the behavior and occurrence of seizures, it seems best to discard a piece of apparatus which does not allow control of these variables.

It is not fair to compare our results, at least with *dba*'s and possibly with Albinos, with the previous results from another standpoint. In our work the mice which died in early seizures might, had they lived, have contributed seizures in the later tests. Thus, even if the seizure rate remained constant, the deaths of the highly susceptible animals, while non-susceptible or little-susceptible mice remained alive, would apparently cause a decrease in seizure rate. The drop in seizure susceptibility in older mice is real, however, for the records of mice which lived throughout the entire testing period showed the same drop in susceptibility in the 40–50-day period. But the absolute rates of older populations are measured in our experiments only for *C-57*'s, and possibly for Albinos, since relatively few of these died.

The work of Witt and Hall (1949) deserves some comment in the light of these results with respect to seizures in *C-57*'s and *dba*'s. Witt and Hall state that the appearance of audiogenic seizures in the house mouse at 30–34 days of age is determined by a single dominant gene, with modifying factors possibly present. Since both strains are seizure-susceptible earlier in life, it would perhaps

be better to conclude from their results that the particular inbred lines which they used differ with respect to a single gene pair, the recessive allele bringing about only early seizure (20-day period), the dominant allele bringing about both early and later seizure (30-day period).

From further work now in progress in this laboratory, it may be stated that seizure incidence and the age of appearance of seizures are both influenced by more than one gene pair. In such a case it is obvious that mere inbreeding, without selection of parents, can produce homogeneously high or low susceptibility stocks only as a result of a series of accidents. Studies of inbred lines allow merely determination of the genic differences between these lines. For full elucidation of the genetic phenomena involved, either many inbred lines differing with respect to many gene pairs must be studied, with the hope that all the possible combinations in the series will thus be turned up, or stocks must be produced by progeny selection in which the genes for high and low incidence or for age modifications are cumulated. In either case, a great amount of further work is needed before fruitful generalizations about the genetics of audiogenic seizures can be made.

SUMMARY

Mice of three strains (Albino, *C-57*, and *dba*) were tested for susceptibility to audiogenic seizures over the age-range 15 to 50 days. The sound stimulus was a 10 kc./sec. note at an average intensity of 110 db. The seizure pattern and preseizure behavior of the mice are described in detail. There were few inter-strain or sex differences in behavior or incidence of seizures. In general, *C-57*'s seem least susceptible and *dba*'s most susceptible, but great individual variation in susceptibility and pattern was found even within the same litter.

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INDIRECT EVIDENCE SUPPORTING OBSERVATIONS ON THE RANGE OF WILD RODENTS

BY C. BROOKE WORTH

Investigators on the home range and wandering of certain small mammals have presented essential data on this subject. By laboriously trapping, marking, releasing, and subsequently retrapping the animals, they have been able to show that most species are characterized by an astonishingly small home range and by an inclination to remain in their territories unless disturbed. Examples of such studies are those of Davis, Emlen, and Stokes (1948) on the brown rat; of Stickel and Stickel (1949) on the cotton rat; of Burt (1940) on the white-footed mouse; of Howard (1949) on the prairie deer mouse; and of Fitch (1948) on the kangaroo rat.

During the course of typhus fever investigations in Florida, 1948 and 1949, large numbers of common native wild rodents were trapped. An unexpected by-product of this activity was the opportunity to make two unrelated observations that support a conclusion generally agreed upon by mammalogists, namely, that in most species adult male rodents wander farther than adult females.

The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Division of The Rockefeller Foundation in co-operation with the Florida State Board of Health.

Materials and methods.—Live trapping was undertaken in order to bleed the animals for typhus immunity tests and also to recover as many ectoparasites as possible. Modified rabbit box traps (Richter and Emlen, 1945) and metal "Hav-a-hart" traps were used almost exclusively. The surviving animals were retained for experimental use.

Trapping stations were usually abandoned when the catch no longer warranted working in those areas, but in some instances trapping was continued regardless of the catch. Two examples of the latter procedure will be considered.

Results.—At a trapping station on the outskirts of Tampa, six "Hav-a-hart" traps were operated for 50 nights, consecutively. Fifty cotton rats, *Sigmodon hispidus*, were caught. The rates of obtaining adult males, adult females, and immature animals are shown in Figure 1.

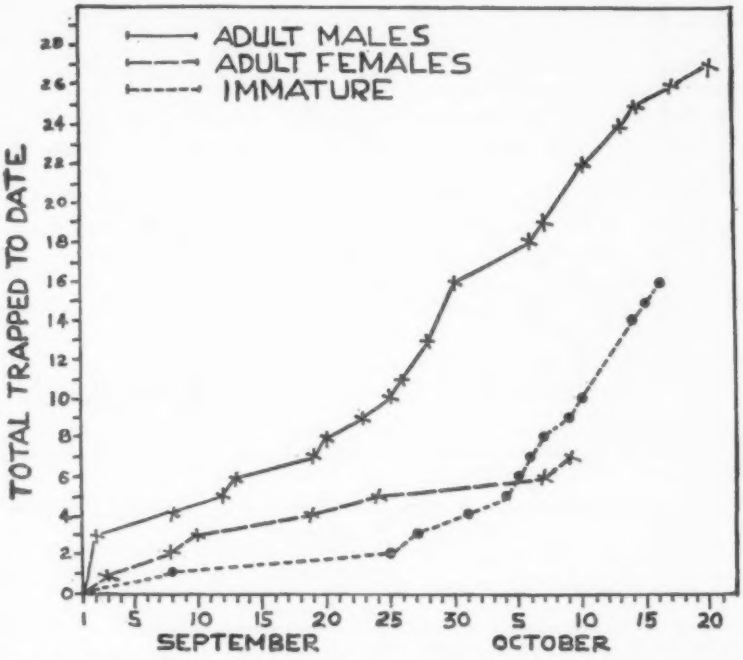

FIG. 1.—Cumulative catches of cotton rats at a trapping station near Tampa, operated for 50 consecutive nights. Trapped animals were removed from the area.

At a number of trapping stations in Everglades National Park, seventy box and "Hav-a-hart" traps were operated for fifteen nights, consecutively. Catches from these stations totaled 78 cotton rats, *Sigmodon hispidus spadicipygus* Bangs, and 40 rice rats, *Oryzomys palustris coloratus* Bangs. Distribution of adult male, adult female, and immature cotton rats followed closely the first fifteen days of the Tampa curves. Data for the rice rats are shown in Figure 2.

Ectoparasite censuses for animals trapped in various parts of Florida in 1948 and 1949 showed a tendency for adult males to be more frequently and more heavily parasitized than adult females. An example of this sort is presented in Table 1, comprising records from cotton rats taken in Everglades National Park.

Discussion.—With reference to ectoparasitic abundance on an animal, it may be logical to presume that the more widely a given host wanders the more para-

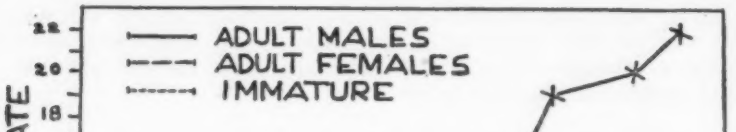

FIG. 2.—Cumulative catches of rice rats at a trapping station in the Everglades Nationa Park, operated for 15 consecutive nights. Trapped animals were removed from the area.

TABLE 1.—*Ectoparasite infestations of 36 adult male and 29 adult female cotton rats in Everglades National Park*

ECTOPARASITE	PER CENT INFESTED		AVERAGE NUMBER PER INFESTED ANIMAL	
	Males	Females	Males	Females
Haemolaelaps glasgowi (mite) (Ewing) (Acarina)	100	86.2	41.9	16.3
Liponyssus bacoti (mite) (Hirst) (Acarina)	41.7	13.7	2.3	1.3
Eutrombicula spp. (chigger) (Acarina)	50.0	55.2	not counted	not counted
Dermacentor variabilis (tick) (Say) (Acarina)	66.7	41.4	7.1	5.7
Hoplopleura hirsuta Ferris (louse) (Anoplura)	22.2	3.4	5.8	1.0
Polygenis gwyni (flea) (C. Fox) (Siphonaptera)	44.4	31.0	2.8	2.0

sites it will encounter and acquire. This may be due to the greater scope of the environment to which the host exposes itself, of the greater numbers of its own species with which it comes into contact, or of both. In the case of cotton rats

in Everglades National Park, one is led to believe, on the basis of ectoparasitic distribution with respect to sex of the host, that adult males have a wider range than adult females.

Continuous trapping in a given location seems to result in the following chain of events. At first adult males and adult females are caught in roughly equal numbers. These animals represent the original inhabitants of the area. As the females are trapped out, motherless animals begin to appear in the traps. Males continue to be caught at the initial rate, although some of these are probably now immigrants. Eventually the females are all caught; then the remaining immature animals are trapped out; but still the stream of males continues.

The trapping area may now be considered as a vacuum with reference to rats. Surrounding this area is rat territory experiencing the normal population pressure. Consequently the most widely ranging members of the population will be first to enter the uncontested trapping area. Once again it is the adult male which makes the adventuresome journey.

Although rice rats in Everglades National Park were trapped for only 15 consecutive nights, the pattern exhibited with respect to sex and age suggests that in this species adult males also wander more distantly than adult females.

Conclusions.—1. Greater numbers of ectoparasites on and more frequent parasitization of adult male cotton rats suggest that they have a wider range than adult females.

2. Continuous trapping in a given area results in a depletion of the original population of cotton rats and rice rats. Subsequent consistent and continuous catching of adult males indicates that these animals have wandered into the territory from adjacent regions, again suggesting a wider range for adult males.

3. The rice rat exhibits a range pattern, with respect to age and sex, similar to that of the cotton rat.

4. These observations support direct evidence obtained by other investigators who have trapped, marked, released and retrapped certain small mammals.

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DETERMINATION OF HAIRS BY IMPRESSIONS

By V. H. H. Williamson

Obscurity due to the transparency of the scalelike structure of hair has been for many years a considerable handicap for their recognized value in identification. Several methods were devised to overcome this handicap, but they proved too crude and involved to be practicable. However, it was later found that impressions of hair rather than hair itself would reveal the scale structure and thus eliminate visual interference from the pigments and cells below. Experiments with various media followed, most of them ending in negative impressions. It was at this point that a joint effort on the part of J. I. Hardy and Thora M. Plitt (U. S. Dept. Int., Fish and Wildlife Service, Wildlife Circular no. 7, 1940) devised an improved method for revealing scale structure with positive impressions. Their imprints were made on a thermoplastic film that softens at a temperature slightly below 100°C. Their technique provides clear, accurate impressions quickly.

The method described in this paper does not improve on the results obtained by Hardy and Plitt, but presents another plastic medium (Gelva) and the technique for its application. Gelva has a decided advantage over other media in that the results are equally as good, yet require much less time and effort.

Gelva is a cold set type of plastic that reaches the proper consistency for hair impressions in about thirty minutes and remains soft enough for impressions over a period of ten to twelve hours. It is easily applied and does not require heating. Positive or negative impressions can be obtained with Gelva and since there is so little to be gained by positive impressions for use in food habits work, the method and key that follow concern negative impressions.

Gelva is the simplest resin derived from the polymerization of vinyl acetate and is a thermoplastic, colorless, granular powder. It is manufactured by the Shawinigan Chemicals Limited in Canada and by the Carbide and Carbon Chemicals Corporation in the United States. (Known as Polyvinyl Acetate in the U.S.) It is supplied in a number of different grades. The viscosity in solution is the distinguishing point between the various grades.

Gelva is readily soluble in organic solvents and sets by the evaporation of the solvent. When spread over an area the surface becomes dry to the touch very rapidly; this has a retarding effect on the evaporation of a small percentage of the solvent underneath, promoting a slow rate of drying. This characteristic is the chief advantage of Gelva as a medium for hair impressions.

A large quantity of Gelva solution can be prepared at one time and will keep indefinitely if stored in sealers to prevent the evaporation of the solvent. The proper solution is readily prepared by adding equal parts by measure of Gelva (V.25) and ethyl alcohol (95 per cent) together in a double boiler and heating over a low flame until all the crystals have dissolved.

The outstanding features of Gelva for the purpose of making hair impressions are: Its slow rate of drying, clearness of impressions, ease and speed in handling, and the ability to store a quantity of prepared solution for an indefinite period

of time. An oven or heating apparatus of any sort is not necessary for hair impressions in this plastic film. Sufficient pressure to imbed the hair in the plastic is all that is required to obtain clear, accurate impressions of the hair scales.

Material:—The materials required for making hair impressions with Gelva are few and simple and are listed below:

1) Stock of Gelva (as prepared above).
2) A number of 3xl microscope slides.
3) Carbon tetrachloride or ether (for cleaning and degreasing).
4) Small press (as illustrated in Fig. 1).
5) Glass stirring rod (for applying Gelva to the slides).
6) One pair of sharp pointed forceps.
7) Small soft brush.

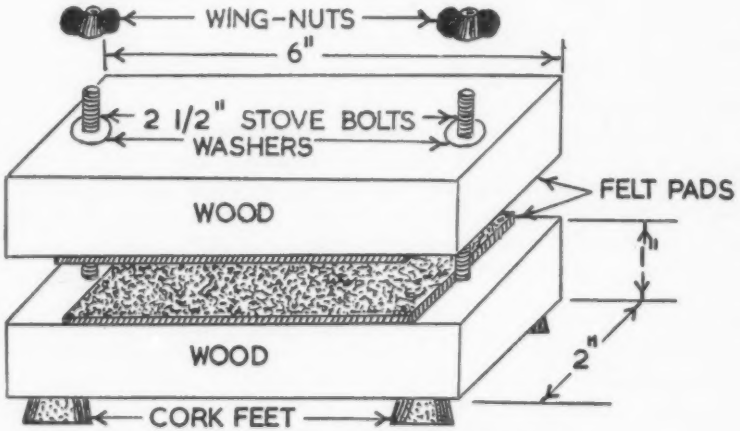

FIG. 1.—Press for making hair impressions

Procedure:—1. With the glass stirring rod apply a layer of Gelva solution (about the thickness of a file card) on ten or more microscope slides. Leave a space clear at the right end of the slide for a label and for handling. A sufficient number of slides should be prepared in advance thus avoiding delay in a long series of impression operations.

2. Spread the prepared slides out on a flat surface and allow to set for about thirty minutes. (Once the slides have set they are then ready for immediate use at any time up to ten hours.)

3. Hairs from which impressions are to be made are cleaned with carbon tetrachloride or ether and allowed to dry. They must be absolutely free from dirt and grease and thoroughly dry to obtain best impressions. (If not perfectly dry the imprints will fade after a short time.) It is a good practice to clean more hairs than are required in order to have extras in case additional impressions are necessary.

4. Place eight or ten of the clean dry hairs horizontally on the plastic film on a prepared slide, with the apex to the left, and cover with a clean microscope slide. A very thin film of grease rubbed over the slide used to cover the hairs while pressing will prevent the plastic from sticking to the slide.

5. Place the sandwich thus formed into the press and tighten the wing nuts with the fingers as tight as possible without using force. (Too much pressure will sometimes distort the imprint.) Leave the pressure on for a few seconds, then release.

6. Remove the sandwich from the press and separate the slides. Remove the hairs from the plastic film with the forceps or the soft brush. (Care must be exercised to avoid scratching the plastic.) The impressions of the hairs in the film are then ready for examination under the microscope.

7. If hair comparsions are desired, place the two hairs as close together as possible, side by side, on the film, and make the impression in the same manner as before.

8. Discarded slides are cleaned by placing them in hot water for a few minutes and peeling off the film.

Positive impressions are readily obtained by applying Gelva to one surface of a cover glass and making the imprint in the regular manner, as with the slides. Allow the film with the impression on it to set thoroughly before inverting and mounting on a microscope slide. Use Clarite or Canada balsam for mounting. (Gelva will dissolve the film if used for mounting.)

Microscope:—A compound microscope, equipped with a substage condenser and fitted with a combination of ocular and objective lenses to obtain powers of 270 or more, is best suited for this method of hair identification. An ocular net (or grid) for gauging the size and shape of scales will be found very helpful, but is not an essential item.

About the method and key:—A study of the structure of cuticular scales of the four Ontario genera of the family *Cervidae* (elk, moose, deer, and caribou) by means of hair impressions, was undertaken to develop a quicker method for hair identification.

Numerous guard hairs taken from various parts of peltry, at different seasons, showed that the cuticular scales remained the same in general character. Obvious differences between each genus provided the breakdown for the key that follows. Hairs that are superficially glossy, such as those of elk and moose, present some difficulty in obtaining clear impressions. This is due to the scales lying flat against the cortex, causing very shallow outlines. It will be noted that this has also been mentioned as a key character. Examination of guard hair from three species of the genus *Rangifer* failed to establish a criterion beyond the genus and, therefore, the key will only pertain to the genus.

This method of hair identification will prove especially valuable in food habits work, since the cuticle does not appear to break down in the process of digestion. Also, slides prepared prior to starting stomach or scat examinations (where hair is likely to be encountered) will simplify and speed the task considerably.

KEY TO THE ONTARIO GENERA OF THE FAMILY CERVIDAE

Note: With the hair impression on a horizontal plane. The length of a scale is described in the direction of the axis of the hair and the width is at right angles to it. All hairs are guard hairs of comparable size (Fig. 2).

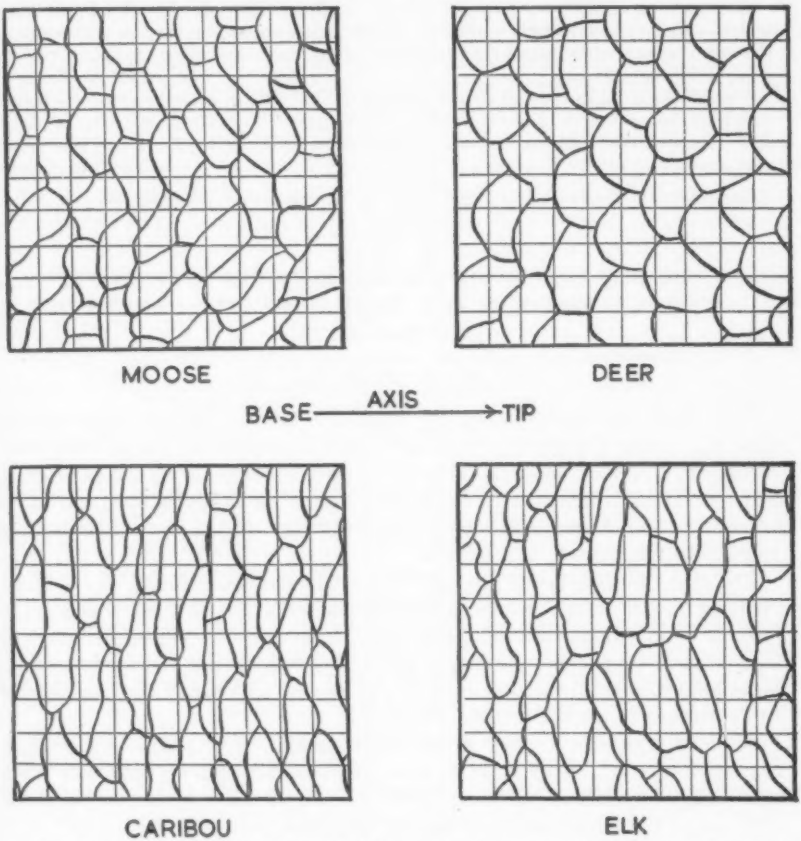

FIG. 2.—Scales drawn from actual hair impressions, approximately 15 mm. from the tip of the hair.

Individual scale nearly equal in length and width.....Group A
Individual scale two or more times wider than long.....Group B

Group A:

Scales rectangular in appearance and quite irregularly arranged. Usually seven to ten scales in the maximum width of the hair. The sides of a number of the scales are formed with a straight line. Clear impressions are hard to obtain due to the scales lying flat to the cortex. (This characteristic gives the actual hair a glossy appearance.)

Moose, *Alces.*

Scales fairly uniform in shape. Usually more than ten scales in the maximum width of the hair. An arc forms one end of the scales. Clear impressions easily obtained due to the scales being slightly raised from the cortex. (This characteristic gives the actual hair a dull appearance.....Deer, *Odocoileus.*

Group B:

The scales are uniformly arranged at right angles to the hair. Usually five or more scales in the maximum width of the hair. Clear impressions quite easy to obtain due to the scales being slightly raised from the cortex. (This characteristic gives the actual hair a fairly dull appearance.).....Caribou, *Rangifer.*

Usually three to five scales in the maximum width of the hair. Scales erratically arranged with a marked variation in the individual scale shapes. Clear impressions hard to obtain due to the scales lying flat to the cortex. (This characteristic gives the actual hair a glossy appearance.).....Elk, *Cervus.*

Royal Ontario Museum of Zoology, Toronto 5, Ontario. Received May 8, 1950.

THE FEEDING HABITS OF POCKET GOPHERS (*THOMOMYS TALPOIDES MOOREI*) IN THE HIGH MOUNTAIN RANGES OF CENTRAL UTAH

By C. M. Aldous

This study was conducted on the Wasatch Plateau about ten miles east of Ephraim, Utah. The general elevation ranges from 9000 to 10,000 feet. Some cattle, and a larger number of sheep, range over this area during the late spring, summer, and early fall months. The area on the summit is largely open with small islands of stunted spruce–fir stands. The vegetation in the open areas consists largely of forbs, grasses, and shrubs.

The term "feeding habits" as used here might more specifically be called the "cutting habits" inasmuch as a part of the vegetation cut off is not consumed as food. It is difficult to determine just what per cent of the vegetation removed from an area by gophers is actually eaten since some is used for nest building, some is stored and not eaten, and a part is taken into the runway and later pushed to the surface in relatively fresh condition.

Although gophers are chiefly subterranean animals, they take some vegetation from aboveground, in addition to root material they get underground while tunneling. The kinds of plants and relative amounts taken by the two methods of feeding differ appreciably and will be considered separately.

Aboveground feeding.—Ordinarily gophers do very little traveling aboveground. One exception to this is during the winter when they make tunnels under the snow. Some of these snow excavations are later filled with earth from their underground runways. In making snow tunnels the gophers come in contact with vegetation that has grown along the line of travel, and some of the vegetation thus encountered is cut off and removed. How much they eat is not known, but there is doubt that they consume very much of the plant material that is old, dry, and tough at that time of year, although no doubt they eat a considerable amount of the fall vegetative growth that they contact along the runway.

The greatest amount of plant removal aboveground is that near the surface

opening of the runway. It has been noted that nearly all vegetation within a radius of approximately eight inches from the tunnel opening is removed before the gophers begin to pile up the mound. Occasionally a little vegetation remains where it was, but in the main all of it is removed and presumably taken into the runway. Vernon Bailey observed that pocket gophers never forage farther out than they can reach by keeping their hind feet in the burrow entrance.

In 1942 a joint study was made by the author and Forest Service Field personnel of the Intermountain Forest and Range Experiment Station to determine the amounts and kinds of vegetation gophers removed at the openings of burrows before mounds were built up. All field work was done inside fenced exclosures. This was to exclude the possibility of domestic livestock removing vegetation at the site of the mound. At each fresh mound the soil was carefully raked away and a weight estimate made of the amount of herbage that had been removed from each species by the gopher. In all, 511 fresh mounds were removed and the affected vegetation appraised. The plant material taken represented 48 species, of which there were 12 grasses, 33 forbs, two grass-like plants and one shrub.

From the standpoint of the frequency and amount of herbage taken, the six most important species were: dandelion (*Taraxacum officinale*), penstemon (*Penstemon rydbergii*), sweet sage (*Artemisia discolor*), yarrow (*Achillea lanulosa*), meadowrue (*Thalictrum fendleri*), and slender wheatgrass (*Agropyron trachycaulum*). These six species made up 71.9 per cent by dry weight of all the plants taken (Table 1). No cut or uncut lupine was found under any of the mounds in the exclosures. Knowing that gophers cut lupine when it occurs at the openings of the burrows, a patch of lupine was located in which there were fresh gopher workings. In order to show the use of this species along with other common range plants, twelve mounds representing two gopher units were removed. The plant materials taken by gophers was estimated to have included 230 plant parts of lupine having the green weight equivalent of 3814 grams, 1525 grams dry weight. Considerable amounts of fresh lupine that had been cut into 1- to 2-inch lengths and pushed out of burrows with the mound dirt have been noted on several occasions. Probably gophers consume the leaves and tender ends of stems and then discard the tough, woody portions.

Plants used to a lesser extent by gophers include: needlegrass (*Stipa lettermani*), aster (*Aster*), fleabane (*Erigeron*), Kentucky bluegrass (*Poa pratensis*), and smooth brome (*Bromus inermis*). This last group, together with the six species mentioned earlier, amounted to 90.3 per cent by dry weight of all the forage removed. The total estimated dry weight of herbage removed under 511 mounds was 1228.5 grams or 2.7 pounds. These studies were conducted at an elevation of 9000–10,000 feet and the results are believed to be representative of the particular plant association and conditions in the area. At the lower elevations, the kinds and amounts of the various plants removed by gophers would undoubtedly be different.

Gophers seemingly are not very selective in the kinds of plants they cut off and remove at the mound, as practically every stem that protrudes from the

TABLE 1.—*Estimate of plant material removed by pocket gophers from aboveground*

PLANT	NO. OF MOUNDS WHERE TAKEN	NO. OF PLANT PARTS TAKEN	GREEN WEIGHT IN GRAMS	GOPHER UNITS*	DRY WEIGHT IN GRAMS	PER CENT OF TOTAL
Taraxacum officinale	241	1,655	1,141	121	285	23.1
Penstemon rydbergii	197	877	429	109	206	16.7
Achillea lanulosa	186	549	210	101	101	8.3
Artemisia discolor	177	618	280	104	154	12.5
Thalictrum fendleri	41	268	223	28	76	6.2
Stipa lettermani	53	238	57	40	48	3.9
Aster sp.	25	227	120	19	60	4.9
Agropyron trachycaulum	54	237	84	40	62	6.0
Vicia americana	21	33	12	19	6	.5
Ranunculus inamoenus	19	29	8	18	2	.2
Agoseris aurantiaca	5	7	9	4	2	.2
Poa pratensis	15	146	24	9	16	1.3
Viola nuttallii	4	11	4	3	2	.2
Trisetum spicatum	2	2	2	2	1	.1
Phleum pratense	6	30	33	4	14	.1
Poa sp.	5	24	6	4	4	.3
Bromus inermis	15	214	130	8	56	4.6
Potentilla pulcherrima	4	7	3	4	1	.1
Carex sp.	2	3	1	2	0	T**
Chenopodium album	3	5	4	3	3	.3
Bromus carinatus	4	9	7	3	5	.4
Geranium viscosissimum	7	9	7	3	3	.3
Polygonum douglasii	2	4	2	2	1	.1
Dactylis glomerata	2	14	7	2	3	.3
Collomia linearis	3	4	2	3	1	.1
Hordeum nodosum	2	9	2	1	1	.1
Stipa columbiana	2	6	2	2	1	.1
Erigeron speciosus	2	4	2	2	1	.1
Frasera speciosa	1	1	4	1	1	.1
Fragaria sp.	1	2	2	1	1	.1
Ligusticum porteri	1	6	25	1	6	.5
Delphinium barbeyi	1	2	20	1	9	.7
Polemonium foliosissimum	2	3	3	1	1	.1
Agoseris pumila	8	18	11	5	3	.3
Castilleja sulphurea	3	42	33	2	18	1.6
Melica bulbosa	2	5	2	1	1	.1
Varleriana edulis	2	4	1	1	0	T
Helenium hoopesi	3	9	13	2	4	.3
Symphoricarpos oreophilus	1	3	2	1	1	.1
Viguiera multiflora	3	10	10	2	6	.5
Eriogonum sp.	23	207	96	17	48	3.9
Stellaria jamesiana	1	8	4	1	2	.2
Lesquerella utahensis	2	2	1	2	0	T
Iva axillaris	3	5	3	2	1	.1
Juncus balticus	2	36	15	1	13	1.0
Melilotus sp.	1	1	1	1	0	T
Orthocarpus sp.	4	17	5	4	3	.3

* Mound or mounds constituting a single gopher's activities.

** T = Trace.

ground is taken. In some cases, for instance, where *Thalictrum* stems are present, it may be easier to pile the dirt when these rather rigid stems are out of the way. Consequently, the cutting and removal of some plants may not necessarily be associated with feeding habits, but may be a reflection of other habits and needs of the animal.

Underground feeding.—The greater part of the food of gophers comes from burrowing just below the surface and collecting the bulk of the plant food encountered as digging progresses. Most of this food is probably eaten where found, while some is cut up into sections, placed in the cheek pouches, and cached in the storeroom. The majority of underground food consists of fleshy taproots, tubers, and corms.

Often the animals do not eat all the food they store. In excavating runways old storerooms full of moldy plant parts frequently are found. The amount of food eaten from the storeroom depends to a large extent on the availability of preferred food found growing along runways.

In the fall of 1942 one runway was excavated in each of five separate sites on the mountain top above Ephraim, Utah. Nests and food caches were collected in each instance and the materials identified and weighed. The plant materials found in storerooms and the green weights of each species are: *Stellaria* tubers, 351 grams; dandelion roots, 1348 grams; *Erythronium*, 81 grams; *Claytonia* bulbs, 146 grams; seeds (unidentified), few.

From the above, and from Table 1, it can be seen that dandelion roots were the most important food items stored. *Stellaria* tubers ranked second, *Claytonia* bulbs third, and *Erythronium* bulbs fourth. Very few grass crowns, and no grass roots or bulbs were found in the nest material.

Summary.—Studies of the feeding and storage habits of the pocket gopher were made on the Wasatch Plateau in Utah at an elevation of 9000–10,000 feet. Work was conducted on fenced plots which prevented grazing by livestock.

While the animals are primarily of subterranean habits, it was found that they utilize considerable quantities of surface vegetation in the immediate vicinity of their mounds. A survey of clipped plants under 511 fresh mounds revealed that 48 species were involved in what amounted to almost complete removal of vegetation. Much of the plant cuttings was stored and used as food. However, some plants were cut and stored which were not subsequently used for forage. It was suspected that the clear cutting of vegetation at prospective mound sites was partly a measure to facilitate subsequent mound formation.

Among foods utilized in underground foraging, dandelion roots were most prominent. Tubers of *Stellaria* and bulbs of *Claytonia* ranked second and third, respectively. The relative amounts of underground plant portions in storage was determined by excavating a runway at each of five different sites.

U. S. Fish and Wildlife Service, Albuquerque, New Mexico. Received April 8, 1950.

OBSERVATIONS ON MAMMALS OF THE SEWARD PENINSULA, ALASKA

By W. B. Quay

This report presents observations on the distribution, life history, and ecology of the mammals encountered on the Seward Peninsula during the summer of 1948. No previous extensive study has been made of the mammals of this region. It is hoped that the following observations will add to the general knowledge and stimulate further investigations.

Published information on the Seward Peninsula mammals is meager and widely scattered through sources of three types: descriptions of faunas, taxonomic reviews, and observations by explorers. Pertinent faunal and distributional papers are those by Bailey and Hendee (1926), and Dufresne (1942). Taxonomic reviews give distributional as well as systematic data, and are numerous and scattered. The distribution and abundance of mammals in former years is often commented upon in the reports of early explorers and field workers. The following publications of the U. S. Geological Survey are of interest in this regard, because they record observations on the wildlife in various parts of Seward Peninsula: Collier, *et al.* (1908), Mendenhall (1901), Moffit (1905), Schrader and Brooks (1900), and Smith and Eakin (1911). In spite of all these sources of information, the total knowledge of the mammals is very slight. The plant names used here are those given by Hultén (1941–1948).

Acknowledgments.—The material presented here is taken from an undergraduate thesis submitted at Harvard College. In this study, I am very grateful to Charles P. Lyman, Barbara Lawrence, and Alfred S. Romer. The Museum of Comparative Zoology, Harvard University, granted financial aid to cover certain expenses and assisted in securing collecting permits. I am grateful to the Geological Survey for employing me on a temporary basis for the summer in Alaska. Appreciation for help rendered by members of the Survey goes especially to Robert F. Black, Robert Reed, David M. Hopkins, and Robert S. Sigafoos. Mr. Sigafoos aided in the identification of plants, but he is in no way responsible for errors that might have subsequently occurred. For loans of specimens, important in determining the relationships of the Seward Peninsula forms, my thanks go to: Austen W. Cameron of the Canadian National Museum, Ottawa; Oliver P. Pearson of the Museum of Vertebrate Zoology, Berkeley; Stanley P. Young of the Biological Survey Section, Fish and Wildlife Service; and Remington Kellogg of the U. S. National Museum.

Description of region.—The Seward Peninsula is separated from eastern Siberia by Bering Strait, and is closer to the Asiatic continent than is any other part of the North American mainland. Hence it is of considerable importance zoogeographically. In size, the peninsula measures about 135 miles from north to south and about 200 miles from east to west. Observations and collections were restricted to the central and southern portions of this area. The most important localities mentioned are shown on the map (Fig. 1). The geographic position of all the localities is described at the close of this article.

Most of the field work was done near Nome, on the south coast of the peninsula, and in the Imuruk Lake area, 100 miles to the north. The Nome area is a part of the Bering coastal plain, which is about three miles wide and is poorly drained The flat coastal plain is underlain by gravel, sand, and silt. Inland from the coastal plain is an undulating upland with local relief of 500 to 1500 feet, underlain by marble and schist. Soils are silty or peaty on the coastal plain and rocky on the lower slopes of hills. On the upper slopes the soil is thin or lacking, and there is bare bedrock or rubble at the surface.

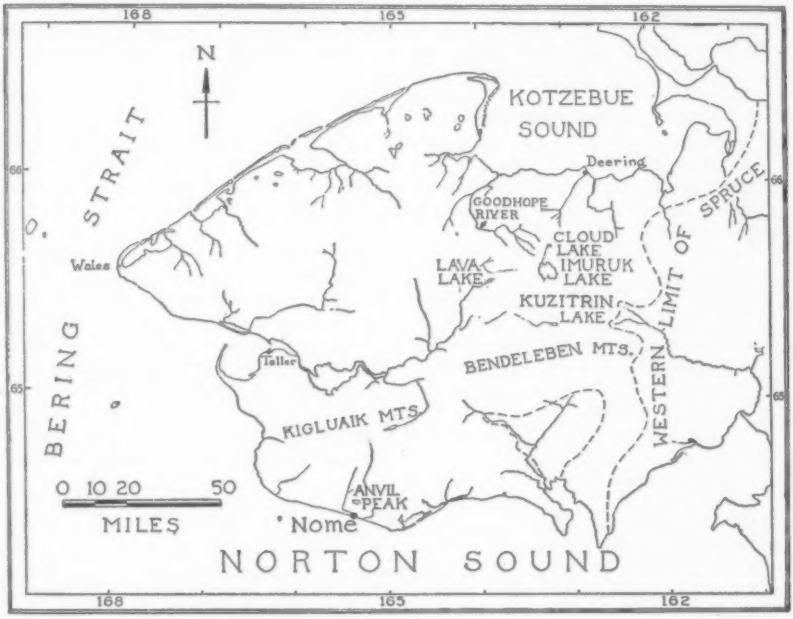

FIG. 1.—Map of the Seward Peninsula, Alaska, showing principal collecting stations and landmarks.

The Imuruk Lake area is a rolling upland, ranging in altitude from 400 to 2000 feet. It is poorly drained and has many lakes and swamps. The bedrock consists of granite, metamorphic rocks, and lava flows. The younger flows have lava rubble at the surface and the youngest, the Lost Jim flow, consists of bare bedrock with soil and vegetation other than lichens found only in sheltered spots. For a detailed description of the Imuruk Lake area, the reader is referred to Hopkins (1949).

Most of the peninsula lies beyond timberline in the tundra plant formation. Cryopedologic surface features, such as solifluction terraces, stone polygons, rubble-fields, and vegetation polygons, are widely distributed. Alders (*Alnus*

crispa), distributed locally over much of the area visited, usually formed the tallest vegetative cover away from water courses.

ACCOUNTS OF SPECIES

Sorex cinereus hollisteri Jackson. A single female with seven embryos, measuring 9 by 6 mm., was collected July 28 in an extensive and heavy growth of the cottongrass, *Eriophorum angustifolium*, bordering Cloud Lake. This area was shared by a dense population of *Microtus oeconomus*.

Sorex tundrensis Merriam. Specimens were collected at Lava Lake, Kuzitrin Lake, and Nome, always in areas of wet, low-lying tundra, and usually in association with *Microtus oeconomus*. Many shrews were trapped in pitfalls which were dug in the coarse sand of the deltas and sand plains around Kuzitrin Lake. Often, when more than one shrew was imprisoned in a pit at the same time, all but one of the captives would be devoured; sometimes only the skin, mandibles, and rostrum would be left of the others.

Digestive tracts of many of the shrews revealed that the greatest part of the fare consisted of insect larvae and earthworms; in two cases, earthworms formed over three-fourths of the stomach contents. The more durable parts of the exoskeletons of adult insects (Coleoptera, Diptera) occasionally were found. In the stomach of one shrew at Kuzitrin Lake a large quantity of the minute floral parts of one of the small grasses was found. The quantity suggested that they may not have been taken in accidentally, but had been eaten deliberately.

The only two tundra shrews that were collected at Nome were lactating females; one contained twelve embryos, ten of which were 2-mm. in diameter, and larger than the remaining two. Two young-adult females collected during the third week of August at Kuzitrin Lake were also lactating. Both shrews taken at Nome had very sharp molt lines, but close examination of the hair and skin indicated no new growth. Jackson (1928: 73) stated that the transition from winter to summer pelage in *tundrensis* usually occurs during April or May. He found fresh summer pelage on specimens collected from various parts of Alaska during the last week of May and the first week of June. The two Nome shrews were collected on June 11 and 23, and it seems likely that their molt had been arrested. It would be interesting to determine the extent of this phenomenon in shrew populations and what bearing the reproductive cycle has upon it.

The tundra shrews collected during the summer represented two age groups. The two collected at Nome and one collected during the last week of August at Kuzitrin Lake were old adults, as shown by the advanced tooth wear, the flattening and broadening of the cranium, and the more heavily developed sagittal and lambdoidal ridges. Thirteen shrews collected at Kuzitrin Lake, from August 14 to 16, and three collected at Lava Lake, from September 4 to 10, were younger adults, having smaller size, less tooth wear, and less mature skulls. Along with these differences in size and structure, old specimens have a much darker and more distinct dorsal stripe than the young-adults. This is notable, since age characteristics in shrew pelages have been rarely noted. However, not enough specimens are available for a complete description of the pelage history.

Ursus sp. A single large brown bear was seen July 22 on the willow covered east side of the Trail Creek valley. On the opposite side of the valley were three caves that could have been utilized at various times by bears. A brown bear had been killed a year or so previously near the Asses Ears, a hill from one to two miles north of Cloud Lake. Hopkins saw bear tracks and signs on the north and south sides of Imuruk Lake during the summer of 1947. A few brown or grizzly bears are reported to have been taken elsewhere on the Peninsula in recent years. The proper species name for the Seward Peninsula bears could not be determined, since the taxonomy of the Alaskan brown and grizzly bears is still in a confused state.

Piles of freshly exposed rocks and peat were frequently found in the region from Cloud Lake to the middle of the Cottonwood Creek valley, and in the region around Kuzitrin Lake. These were interpreted as the work of either bears or wolverines, searching for

ground squirrels or voles. The ground squirrel tunnels were frequently exposed around Kuzitrin Lake. Near the Asses Ears and along Cottonwood Creek were found large peat mounds, still bearing green vegetation and completely overturned, exposing the deeper galleries of voles. Each peat mound, probably weighing a few hundred pounds, appeared to have been swept off the ground by a single blow.

Thalarctos maritimus (Phipps). Eskimos from various parts of the Peninsula sometimes commented on killing polar bears which came ashore during the winter; this was especially true along the northern coast. Similar records have been mentioned by Bailey and Hendee (1926: 13) and by Collier, *et al.* (1908: 56).

Mustela erminea arctica Merriam. One female was collected in some lava rubble near the head of Cottonwood Creek. Many others were seen at nearly all places visited during the summer. At Imuruk Lake, Lava Lake, and Cottonwood Creek, they were frequently seen in the lava flows, especially near the edges. At Kuzitrin Lake other members of the party saw several weasels in boulder rubble at the foot of a nivation niche. Weasels could usually be found in any rocky area. They were remarkably curious, sometimes approaching within a distance of six feet. On the basis of size, most if not all weasels seen during the summer were referable to this species.

Mustela vison ingens (Osgood). A mink was seen at Imuruk Lake during the summer of 1947 by geologists working there, but none were seen during the 1948 season.

Gulo luscus (Linnaeus). Hopkins reported seeing a dead wolverine on the shore of Imuruk Lake during the 1947 summer. At Kuzitrin Lake, in August of 1948, members of the party observed a wolverine at close range on the rocky slope north of the lake. The distinctive characteristics of color and form were clearly seen.

Vulpes fulva alascensis Merriam. One fearless red fox was seen north of Cloud Lake Near the Asses Ears; another was seen on the northwest side of Kuzitrin Lake. Mandibles and skull bones were found at the surface in one of the caves on Trail Creek. Also, during June of 1948, members of the party saw a red fox on the Upper Inmachuck River. During the summer of 1947 geologists in the Imuruk Lake area saw foxes on several occasions. One was seen on the Lost Jim flow, two miles south of Imuruk Lake and well within the lava area. A bitch with three or four pups was seen at least three times about a half mile from the shore of Imuruk Lake. Here they were seen on the lava rubble, in which they had burrows. Some of the foxes seen in the Imuruk Lake region are reported to have been cross foxes, and the description given of them makes it likely. During the summer of 1949 foxes were seen at three places by geologists working in the south coastal area. On the north side of Point Spencer a cross fox was chased for two miles along the beach and was seen through binoculars at close range. A red fox was shot on the north side of the Sinuk River, about three miles south of Glacial Lake. Another red fox was seen on three or four occasions on Anvil Peak by Hopkins.

Canis lupus tundrarum Miller. Signs and tracks of wolves, during 1948, were few and were restricted to the caves on Trail Creek.

Citellus parryi ablusus Osgood. Specimens were collected at Cooper Gulch (on the southeast slope of Anvil Peak), Cottonwood Creek (about six miles northwest of Cloud Lake), Magnet Creek (about two miles north of Cloud Lake), Kuzitrin Lake, and Trail Creek (skull in cave deposit). In addition, ground squirrels were seen in the central Bendeleben Mountains and in the Nome River valley.

Ground squirrels, locally distributed and abundant where they are present, seem to have definite requirements as to habitat. At all localities visited they were found only where the soil was well drained—on the slopes of hills and the sides of valleys; on the banks of rivers and lakes; and on solifluction terraces and other large, raised areas of mineral soil. At Anvil Peak, Kuzitrin Lake, and Cottonwood and Magnet creeks they were abundant on the large rock and solifluction terraces, in the forward surfaces of which they had their burrows. Two burrows in such terraces on Anvil Peak were uncovered and mapped (Fig. 2, A and B). In many cases the burrows were in the rockier parts of the terraces, and often seemed to be designed so that they might be covered by the maximum number of

large rocks. On a broad delta at Kuzitrin Lake, one isolated boulder lying on the surface of the ground covered the burrow-system of a single ground squirrel. When the burrows were in terraces or banks, the main tunnel usually ran parallel to the forward scarp and several feet from it. In regions where ground squirrels were abundant, the tunneling may have influenced the downward movement of the terraces and have accelerated erosion.

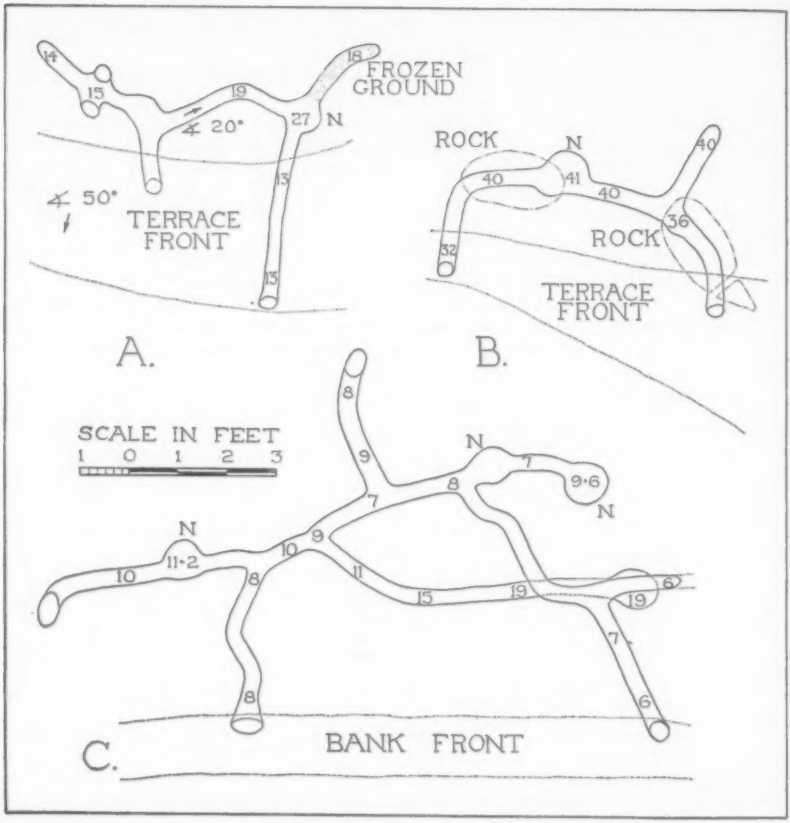

FIG. 2.—Burrow systems of *Citellus parryi ablusus;* depths (vertical) to floor of tunnel are indicated in inches; areas marked "N" are nest cavities lined with rotted grass. When the layer of grass is greater than one inch deep, the depth is indicated by a second figure, following the depth to tunnel floor figure. A and B are tunnels uncovered on June 18 at Anvil Peak; C was uncovered on August 25 at Kuzitrin Lake.

Along Magnet Creek, some squirrels occupied burrows in the high creek banks; at Kuzitrin Lake, the sandy deltaic deposits of the lake banks were sometimes inhabited (Fig. 2, C). The level and shallowly-thawed soils peripheral to areas of steeper terrain were utilized largely by younger animals. In the central area of the Peninsula, from Imuruk Lake to Lava Lake and environs, the terrain had low relief and poor drainage. Here no ground squirrels nor signs of their presence were seen.

The burrow systems shown in Figure 2 illustrate the depth and plan. The June tunnels were short and freshly dug beyond the nest cavities, as was shown by fresh dirt piled at the entrances and the exposure of frozen ground in the floor of an extension. The deepest spots in the burrows were always the circular cavities containing rotted vegetation. In each of the two June burrows examined, there was a single nest cavity. It seemed likely that these were dug at least before the preceding winter and were occupied through the winter, since (1) the nest cavities were near or slightly below the upper surface of the frozen ground in the surrounding soil; (2) the cavities were lined with rotted and soggy vegetation, probably gathered the preceding year, or perhaps earlier; (3) the winter snow had melted from the area only a week or two previously, and snow was still present on the more shaded slopes. Presumably, the thawing of the surface soil had started but a short time before I uncovered the burrows. The plant material found in the nest cavities of all three burrows was greatly disintegrated and did not appear to have been stored for feeding purposes. I believe that a single squirrel lived in each of the burrows which were uncovered. The late summer tunnel system was more complex than the spring ones, but whether this was a widespread condition was not determined.

How the hibernating ground squirrels survive the winter, and the ecological factors involved in their survival, present interesting problems. In the areas where there were squirrels, summer thaw rarely extended to a depth of more than four feet. On many slopes the greatest depth of thaw was found near the forward edge of soil or rock terraces. In winter, the thawed layer is frozen down to the permafrost or perennially frozen ground lying below. The temperature of the ground squirrel burrows in the winter and the amount of insulation provided by snow and frozen soil is unknown, but the annual absolute minimum temperatures range from −35° F. to −60° F. at nearby weather stations.

Cheek pouches of several ground squirrels collected on Anvil Peak in June contained the flowers, buds, and leaves of a great many plants, including species of *Ledum*, *Eriophorum* (leaves), and *Vaccinium*.

An individual collected at Kuzitrin Lake was heavily parasitized by lice (*Neohaematopinus laeviusculus* (Grube)).

Pellets, presumably of the snowy owl, contained great numbers of ground squirrel bones. Tunnels unearthed by bears or wolverines were sometimes seen.

The people of the Nome region refer to the ground squirrels as "marmots" and on several occasions when living or dead ground squirrels were shown to them, this fact was verified. No true marmots (*Marmota*) were seen in any of the areas visited, but they may have been present elsewhere.

Lemmus trimucronatus alascensis Merriam. An adult female, bearing six advanced fetuses measuring 25 x 18 mm., was collected at Cloud Lake on July 20. No other lemmings were collected. This one lemming was trapped in a wet *Carex-Eriophorum* tundra area, inhabited by *Microtus oeconomus*.

No *Lemmus* remains were found in old owl pellets and the reports of the permanent and former residents on the peninsula were indefinite as to the past occurrence and abundance of lemmings.

Dicrostonyx groenlandicus rubricatus (Richardson). The only specimens of *Dicrostonyx* found during the 1948 season were in owl pellets on the tundra near Nome. However, *Dicrostonyx* is reputed to be a common mammal in the Bering Strait region. The pellets which were found near Nome consisted entirely of the remains of collared lemmings; all had been captured during the winter, as was evident by the white fur and the development of the peculiar long claws. No lemmings were trapped in the many quadrats set in this area in June, 1948. The degree of preservation of the pellets suggested that they had been deposited only a winter or two before, and a possible population peak may have occurred at that time.

Clethrionomys rutilus dawsoni (Merriam). The red-backed voles were found in a wider variety of habitats than any other small mammal species. They were collected at Lava Lake, Kuzitrin Lake, Mount Boyan, and Trail Creek (skull found in cave). Near the shores of Lava and Kuzitrin lakes, red-backed voles were found in the damp tundra areas occu-

pied by the two species of *Microtus*. On the Lost Jim lava flow, in the vicinity of Lava Lake, six quadrats and several trap-lines were set in the various habitats on the lava flow and at its border. The areas trapped were as much as three miles apart. In 481 trap-nights, red-backed voles were the only small mammals taken on the lava away from the edges. On the flow they were found only within seventy feet of alder clumps (*Alnus crispa*). These alder clumps were rarely more than ten feet in diameter and were less than ten feet in height; the distribution of alders on the lava flow was irregular and sparse. On the lava field, grasses and sedges were sparse also; heaths and low shrubby vegetation were common in some areas. The grass, *Hierochloë alpina*, and the sedges, *Carex lugens* and *Carex vaginata*, were the species usually found. Other plants found on the lava with *Clethrionomys* were: *Betula nana* ssp. *exilis*, *Ledum palustre* ssp. *decumbens*, *Loiseleuria procumbens*, *Saxifraga bronchialis* ssp. *Funstonii*, *Vaccinium uliginosum*, *Dryopterus fragrans*, *Salix pulchra*, and *Vaccinium Vitis-idaea* ssp. *minus*. The upper part of the alimentary canal of one *Clethrionomys*, trapped on the lava, contained many small pieces of leaves of *Carex lugens* (sp. ?).

Red-backed voles were captured in late August at the summit of Mount Boyan, a small mountain about a mile south of Kuzitrin Lake in the Bendeleben Mountains. Mount Boyan is more than 3000 feet in altitude and stands 1760 feet above the lake. The summit, several acres in area, is rather flat. Surface material consists of bouldery soil arranged in stone polygons. The polygons are lines of jumbled boulders separating polygonal patches of gravelly soil about eight feet in diameter. The soil patches form but a small fraction of the total surface area and are largely bare of vegetation except at the edges and in sheltered places. Lichens are abundant over the rocks, but only four species of vascular plants occur: *Carex nesophila*, two low heaths, and a dwarf willow. The soil on the summit thawed only a few inches below the surface, and only during the later part of the day. About a week after the traps were removed, the entire slope of the mountain was covered with snow that probably remained until the following summer. This mountain area is partially free of snow probably less than two months during the year.

A quadrat was set on the summit from August 20 to 22; several other quadrats were set at various levels down the north slope. On the summit, two red-backed voles were caught in traps set in the cracks between the boulders at the edges of the polygons. No other evidences of mammals of any kind were present. A hundred feet below, on the north slope, two more red-backed voles were trapped. All of the voles appeared to be adults and normal in all respects. From the meager evidence of two quadrats set in fairly typical areas, a population density of two to five voles per acre was estimated for this habitat.

External parasites were not common. Mites (*Acarina*) were usually plentiful, however, and some of the vole stomachs contained many large nematodes.

A female trapped on July 1 at Lava Lake contained seven fetuses, measuring 20 x 11 mm. Two young voles, which probably had not been out of the nest for more than a week or two, also were trapped on July 1 at Lava Lake.

Microtus oeconomus operarius (Nelson). Specimens were collected at Anvil Peak, Cloud Lake, Imuruk Lake, Kuzitrin Lake, Mount Boyan, and Nome. This was the most widespread and abundant small mammal encountered.

In all areas where mature *oeconomus* voles were found, the surface of the turf was covered by water during most of the summer, leaving only scattered hillocks of peat above the water level. This condition is general over vast areas of the tundra where the drainage is poor and the slope is slight. In very wet areas bordering lakes or streams, the *oeconomus* population was especially dense. In large continuous swampy areas and swales, *oeconomus* was the only species of *Microtus* present. Several quadrats were set in large swales draining into Lava Lake. These swales possessed the same dominant plant species; the most abundant and characteristic were *Eriophorum angustifolium*, *Carex aquatilis*, and *Salix pulchra*. The correlation of vegetation with *Microtus* distribution across a small swale at Lava Lake is shown in Figure 3, and will be discussed further in relation to the habitat of *Microtus miurus oreas*. The average two-day yield from fifty-foot quadrats in a large swale at Lava Lake was four *Microtus oeconomus*. The three quadrats used had sixteen traps each.

The only place where *oeconomus* was found in a habitat other than those already described, was on the steep north slope of Mount Boyan. Here, in a particularly wet and well-vegetated area of soil between two stone stripes, several immature *oeconomus* were trapped. Several hundred feet below the rock stripes are rock terraces with exceedingly lush and swampy areas below the frontal scarps. Crisscrossing these swampy places were many runways of *oeconomus*, and several adults were seen here. It is likely that the immature voles collected on the upper slope were colonizing a less favorable environment.

The digestive tracts of many voles were examined for identifiable food remains. Although the masticated food was usually unrecognizable, the plant contents of the upper esophagus and the sides and back of the mouth could be identified in a dozen specimens. Small sections of *Carex* leaves were found most frequently. Also, commonly present were the more succulent leaves and stalks of *Eriophorum angustifolium*. Leaves of *Vaccinium uliginosum* and sprigs of moss were sometimes present. Along the well-marked runways of this vole, small piles of the cut lengths of sedge (*Carex*) and cottongrass (*Eriophorum angustifolium*) leaves were abundant.

At many localities, burrows had been dug by these voles into the low peat hillocks, which stood just above the water level of the marshy tundra. At the mouths of these burrows, great quantities of peat were spread out over an area of a square foot or more. Where the voles were especially abundant, two-thirds of the tundra surface was covered with freshly exposed peat. This was most noticeable during the early part of the summer, particularly near Nome and Cloud Lake. The bringing of peat to the surface of the soil, by voles, may be significant in churning the upper layers of peat and in affecting its mode of deposition.

Bordering the lava flows around Lava Lake, there were swampy areas dammed by the lava. A quadrat set on the border of the Lost Jim flow demonstrated that *oeconomus* probably does not venture on to the lava, from the swampy tundra, farther than about fifty feet. Quadrats on the lava flow and far from its edges never produced any tundra voles, nor were there any signs of them in these places. Possibly tundra voles are present on older flows where more soil and vegetation is available.

Weasels were usually abundant at the borders of lava flows and other rocky areas and probably preyed heavily on the neighboring vole populations. A short-eared owl (*Asio f. flammeus*) collected one August evening at Kuzitrin Lake, contained remains of three *oeconomus* in its stomach.

Specimens of *oeconomus* examined shortly after capture were often heavily parasitized by fleas (*Peromyscopsylla hamifer longiloba* Jordan), sucking lice (*Polyplax alaskensis* Ewing), and mites (*Acarina*). When lice were present, the deeper hairs of the lower back and sides were dotted with nits.

One female tundra vole, trapped at Nome, June 23, contained six embryos, 8 mm. in diameter. A female, collected at Lava Lake, July 6, contained seven embryos, 7 mm. in diameter. The adult males trapped during the summer had prominent glandular areas over the hips. Few of the females examined showed any signs of hip glands.

Microtus miurus oreas Osgood. Specimens were collected at Anvil Peak, Kuzitrin Lake, Lava Lake, Magnet Creek, and Mount Boyan. It is likely that *miurus* is widely distributed over the peninsula, wherever the favorable habitat exists.

This vole was less generally distributed than *oeconomus* and seemed to have more critical habitat requirements. It appeared to avoid the wet areas where standing water was present at the surface, and where *oeconomus* was indigenous. The usual habitat was the moist tundra bordering watery areas. Characteristic places where they were found included the moist areas on solifluction terraces on the lower slopes of hills and ridges; the moist areas along the tops of lake and river banks; peat mounds and other small areas of raised ground surrounded by wet tundra; and dryer areas bordering swales and extensive marshes. On the higher tundra slopes, where many large cottongrass tussocks were present, voles were scarce. In regions where wet tundra was interspersed with raised peat mounds, *miurus* was found on raised ground, while but a few feet away *oeconomus* was present in the watery

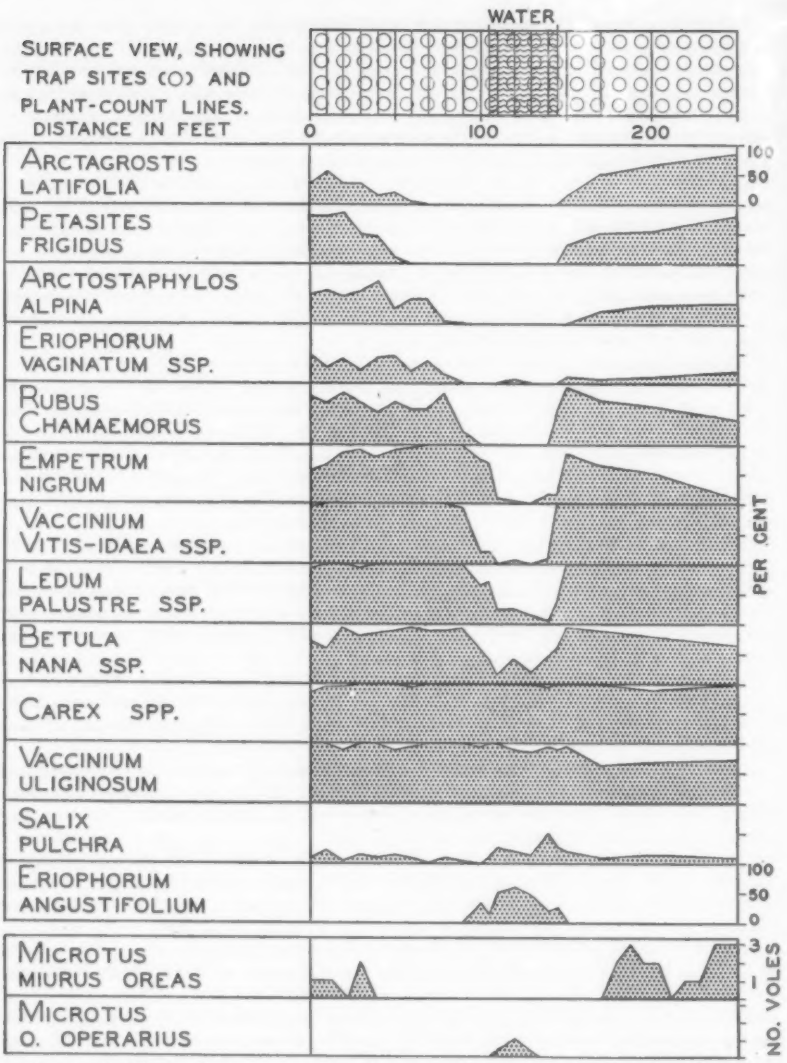

FIG. 3.—Profile of plant cover and small mammal distribution across a swale at Lava Lake, August, 1948.

tracts between mounds; this situation was observed at Kuzitrin Lake and Magnet Creek. *Microtus miurus* was commonly found on the frontal scarps and more heavily vegetated portions of solifluction lobes and terraces, where their burrows sometimes honey-combed the surface, as observed at Anvil Peak, Kuzitrin Lake, and Magnet Creek. Where the

terraces were large and had exceptionally wet places below the frontal escarpments, *oeconomus* was found in the low marshy areas and *miurus* on the forward slopes and frontal portions of the terraces above. Bordering lakes and streams, a similar relationship was true; *oeconomus* occupied the marshy areas directly adjoining the bodies of water and *miurus* occupied the peaty banks or slopes above.

At Lava Lake the topography is smooth and undulating; drainage into the lake is largely by way of broad swales descending the convex slopes. It was found that *oeconomus* occupied the swales, while *miurus* occupied the borders. A 250-foot profile was made across one such swale to establish the correlation of vegetation with the presence of these two species of *Microtus* (Fig. 3). Across a swale on the south side of the lake, five fifty-foot quadrats were set in a continuous line. Each quadrat contained sixteen traps set at equal intervals. The plant species present within areas of one square foot were noted at 2½-foot intervals in the quadrats along lines parallel to the axis of the swale. These lines are represented by the vertical lines in the upper diagram of Figure 3. The intervals between lines varied from 5 to 50 feet, depending upon the change in the vegetative cover. Along each line, 20 sample-one-square-foot plots were studied; the per cent of the 20 plots in which a particular plant species was present is represented for each species on the graph in Figure 3. The percentage of the area stippled opposite each species on the graph represents the percentage of plots in which the species was present. The graph shows in a rough way the type of plant cover present along axes parallel to the axis of the swale. The part of the swale with water above the surface of the peat is that shown under the word "water" in the figure. The numbers of voles trapped along lines parallel to the swale are indicated in the lower set of graphs. There is an obvious correlation of *Microtus oeconomus* with the watery, *Eriophorum angustifolium* part of the swale. The actual environmental factors which govern the habitat distribution of the two voles were not discovered, but the correlations in the distribution of plant and animal species are steps toward the solution of this problem. At other localities the correlations between the two species and the vegetation were the same. I believe that reconnaissance of the vegetation and the ground surface, either in the field or on aerial photographs, would give some indication of the species present at other localities on the peninsula. However, the data presented here are the products of only one season's observations and great changes in the numbers of individuals of either species may possibly alter the ecological and interspecies relationships.

Only a few of the *miurus* collected contained any identifiable food remains. *Carex* leaves were found most often; leaves of *Petasites frigidus* were found in one specimen. On the terraces and soil stripes on the north side of Mount Boyan, there were thriving colonies of *miurus*. Along their runways and at the mouths of their burrows, the leaves of *Carex nesophila* and *Artemesia arctica* were often clipped, and bore the scars of small rodent teeth. *Microtus miurus* was the most common mammal at the places where this was noticed, and it is likely that it was the species responsible.

In the series of 58 *miurus* collected during the summer, there were two distinct age groups. Since nearly all of the collecting was done in quadrats, a representative sample of the population probably was obtained. A frequency curve of the total lengths of individuals has two prominent and widely separated peaks. The first occurs in the range of lengths from 105 to 125 mm., and the second from 140 to 155 mm. There were more than twice as many animals in the area of the first peak as in the area of the second. This indicates the degree to which the younger animals dominated the population in abundance. The wide separation of the two peaks may indicate a restricted breeding season. A similar frequency curve based on 67 *oeconomus* shows two peaks, but the peaks are poorly defined and nearly equal in area. This difference in the population composition of the two species probably has some bearing on the problem of why *miurus* fluctuates widely in numbers and *oeconomus* does not (Gilmore, 1946; Dixon, 1938). Another difference in the populations of the two species is that *miurus* is markedly colonial, while *oeconomus* appears not to be. *Microtus miurus* was usually found in groups of one adult, of either sex, and several small subadults. This is demonstrated in Figure 3, where three colonies are represented in the

miurus graph, one on the left side and two on the right side of the swale. It is probable that the colonial habit is a factor involved in promoting large populations.

External parasites included sucking lice (*Polyplax alaskensis* Ewing) and mites (*Acarina*).

A series of *miurus* collected at Lava Lake, July 7 to 11, were weighed shortly after their capture. There appeared to be no sexual difference in weight; there was quite great individual variation, however. A series of eight adults (total length, 143–153 mm.) averaged 44.6 grams (35.7–52.1); ten subadults (total length, 95–119 mm.) averaged 12.9 grams (11.0–15.3).

Ondatra zibethica spatulata Osgood. Muskrats were seen frequently throughout the summer at Lava Lake, where they appeared to be common. None were seen, however, at Cloud Lake, nor were there the slightest signs of their presence. None were seen at Mountain Lake, but they may have been present. The Eskimos reported to other members of the party that they trap muskrats at a large lake west of Deering. It is likely that muskrats are locally distributed throughout the peninsula.

The extraordinary fearlessness of the muskrats at Lava Lake enabled close observations to be made of them. During the early summer a pair frequented the shore near our campsite and sometimes approached us within ten feet. Most of the feeding activity of the muskrats at camp during early July was centered around the period from 10:00 P.M. to 9:00 A.M. At this season it is light 24 hours a day. The feeding routine usually consisted of ten- to twenty-minute periods of diving and feeding, usually about thirty to eighty feet from shore, separated by one- to six-minute periods of resting, grooming, and dozing on offshore objects rising near or above the water surface. A muskrat while feeding would dive beneath the surface for intervals of ten to thirty seconds and then rise and float at the surface for periods of a minute or more while chewing the food that was carried up.

Later in the summer a subadult muskrat frequented the shore near our camp and proved itself to be even less wary than the two adults observed earlier in the season. This smaller individual could be watched from a distance of two feet without its least concern so long as no sudden movements were made. From this distance, the vegetation that the animal ate could be observed and later identified from the fragments that remained. These proved to be of *Hippuris vulgaris*, *Potamogeton perfoliatus*, and *Potamogeton* cf. *vaginatus*, all aquatic green plants growing nearby.

Lepus othus Merriam. The arctic hare has been reported from many localities throughout the peninsula, but the population abundance is variable. During 1947 and 1948 they were rare, according to the reports of people living there and the writer's own experience. The only signs of their presence noted, during the summer of 1948, were two molar teeth found in cave deposits on Trail Creek.

LOCALITIES

Anvil Peak. A small mountain 4½ miles N of Nome.

Asses Ears. A prominent hill about 1½ miles N of Cloud Lake.

Cloud Lake. A lake located at Lat. 65°43′ N, Long. 163°14′ W, about 5 miles N of Imuruk Lake.

Cooper Gulch. A small valley on the south side of Anvil Peak.

Cottonwood Creek. An eastern tributary of the Goodhope River; localities are from 3 to 7 miles WNW of Cloud Lake.

Deering. A village on the northern coast, at the mouth of the Inmachuk River.

Imuruk Lake. A large lake about 40 miles SSW of Deering.

Kuzitrin Lake. A lake located at Lat. 65°23′ N, Long. 163°15′ W; the lake is 3 miles long and is drained by the Kuzitrin River.

Lava Lake. A lake located at Lat. 65°35′ N, Long. 163°55′ W; the lake is about 1½ miles long and is drained by a tributary of the Noxapaga River.

Magnet Creek. A western tributary of the Pinnell River; locality is about 2 miles N of Cloud Lake and ½ mile WNW of Asses Ears.

Mount Boyan. A small mountain located at Lat. 65°20′45″ N, Long. 163°14′5″ W, at the north front of the Bendeleben Mountains, 2 miles S of Kuzitrin Lake.

Nome. A large town on the southern coast and at the mouth of the Snake River.

Point Spencer. The cape on the southwest side of Port Clarence and about 18 miles SW of Teller.

Sinuk River. A river about 25 miles WNW of Nome.

Trail Creek. A tributary of Cottonwood Creek, 7 miles WNW of Cloud Lake.

Upper Inmachuk River. A river on the northern coast; locality is about 16 miles SW of Deering.

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THE MAMMALS OF BIG BLACK MOUNTAIN, HARLAN COUNTY, KENTUCKY

By Roger W. Barbour

Big Black Mountain lies in southeastern Kentucky and adjacent Virginia, occupying parts of Harlan County, Kentucky, and Wise County, Virginia. Highway 160, between Lynch, Kentucky, and Appalachia, Virginia, crosses the mountain; the highest point in Kentucky (elevation 4150 feet) is some half mile west of the highway. About a mile northwest of this peak is a second height, indicated on the United States Geological Survey Estillville Sheet to have an elevation of 4150 feet or more. On this second peak the Civil Aeronautics Authority maintains the Glenbrook Visual-Aural Range Station. According to an engineer who surveyed this area for the station, the elevation of this peak is 4140 feet. With this station as a center, a circle with a four mile radius would include practically every point at which collections discussed in this paper were made. The only collections made outside this area and included were from the Poor Fork of the Cumberland River between the towns of Cumberland and Harlan, Kentucky, and two areas on Pine Mountain, one near Cumberland, and the other near Rosspoint, some four miles from the town of Harlan.

This study was initiated on July 19, 1939, and is the result of four collecting trips to the area. The period July 19–August 18, 1939, was spent in the area, the time equally divided between the community of Rosspoint and the summit of Big Black Mountain, near Lynch. On May 3–4, 1940, I accompanied a party from Morehead State College, Morehead, Kentucky, to the area. On July 3, 1946, I accompanied a party of three to the summit of the mountain, to remain until July 7. On June 4, 1948, my family and I made camp near the Glenbrook Visual-Aural Range Station and remained there until September 1, 1948.

During these four trips, over 350 mammal skins were prepared, most of them collected in Kentucky. The majority of the skins are in my personal collection; some are in the Cornell University collections, while a few are deposited in the United States National Museum.

Big Black Mountain is the highest point of the Cumberland Mountain Section, the physiography of which has been treated by Fenneman (1938). The exposed rocks of the area under consideration belong to the Pennsylvanian series. Bedrock is exposed in but few places other than stream beds; the region is generally covered by a deep soil mantle. The geology of the area has been treated by the United States Geological Survey (1894).

The mammalian fauna of the mountainous areas of eastern Kentucky and adjacent states is of considerable interest. It is here that certain northern species reach the southern limits of their range; here some southern species reach the northern limits of their range; here is a region of intergradation of various northern and southern geographic races; and here a few geographic races are confined.

This paper presents information on thirty-two species and subspecies of mammals known to occur on Big Black Mountain in southeastern Kentucky and adjacent Virginia. They may be divided into five distributional categories:

1. Northern species, near the southern limits of their range, include, among others, *Parascalops breweri*, *Sorex cinereus*, *Sorex fumeus*, *Myotis subulatus*, *Napaeozapus insignis*, and *Sylvilagus transitionalis*.

2. Southern species, near the northern limits of its range, includes *Peromyscus nuttalli*.

3. Species of widespread distribution, both to the north and south of the area, include *Didelphis virginiana*, *Myotis lucifugus*, *Eptesicus fuscus*, *Lasiurus borealis*, *Urocyon cinereoargenteus*, *Marmota monax*, and others.

4. Geographic races confined to the general area include *Clethrionomys gapperi maurus*, *Blarina brevicauda churchi*, and *Peromyscus maniculatus nubiterrae*.

5. Among species showing intergradation between northern and southern geographic races in the area may be listed: *Tamias striatus*, *Sciurus carolinensis*, *Glaucomys volans*, *Reithrodontomys humulis*, and *Peromyscus leucopus*.

One of the striking features of the mammalian fauna of the Big Black Mountain area is the apparent absence of certain species commonly encountered elsewhere in the southern Appalachians. No skunks nor meadow voles were collected; no indication of their presence was observed. Residents informed me there were no skunks in the area.

In the following annotated list all measurements are expressed in millimeters except where otherwise noted; averages are given first, followed by extremes in parentheses. Males were assumed to be in breeding condition when the tubules of the cauda epididymis were visible macroscopically.

This is a portion of a doctoral thesis, including accounts of the amphibians, reptiles, and mammals of Big Black Mountain, submitted to the graduate school of Cornell University, Ithaca, New York. The writer is indebted to Dr. William J. Hamilton, Jr., for advice and suggestions during the course of the study, and critical reading of the manuscript.

ACCOUNTS OF SPECIES

Didelphis virginiana virginiana Kerr. Virginia opossum.—Two specimens were taken, one killed on the highway at an elevation of 3300 feet and the other collected at an elevation of 4100 feet. The latter specimen was taken in a trap set for raccoons in a swampy cove of mixed mesophytic forest consisting primarily of second growth beech, birch, and maple. According to natives, the opossum is fairly common at lower elevations, but rarely found about the summit of the mountain. The stomach of one individual contained the remains of five snails, one ground beetle, and considerable vegetable debris—dead leaves, bits of stems, and a few fern frond tips.

A lactating female was taken on August 14, 1948. Eight teats were obviously enlarged, but diligent search for the young was fruitless.

Parascalops breweri (Bachman). Brewer's mole.—Four specimens were taken from a mixed mesophytic forest at an elevation of 3800 feet. Tunnels were observed at elevations ranging from 2000 to 4100 feet, and one individual was observed at an elevation of 4000 feet.

This mole inhabited open fields, but was more abundant in damp woodland (as judged by abundance of tunnels). Burrows were abundant in one open area of loose soil at about the 4000-foot level. Dominant plants of the area were *Potentilla simplex*, *Fragaria virginia*, and *Lysimachia quadrifolia*. None of the specimens (collected June 29–July 3) were in breeding condition. On June 29, 1948, a snap-back mouse trap was set in a tunnel under the leaf mould at an elevation of 3800 feet. Next morning the trap was found pushed full of dirt,

indicating the workings of a mole. On the following night an adult male mole was taken. Next night, the trap caught nothing. On the night of July 2, a smoky shrew was captured, and on the night of July 3, a second mole, this time an adult female. Three additional days of trapping took no more animals.

Early in the morning of August 13, 1948, I observed a mole tunnel that had been dug across a path the preceding night. The tunnel was stamped down; within an hour it was repaired. Four times that day I closed the tunnel, and each time it was reopened. A trap was set that night on each side of the path, on a level with the bottom of the tunnel; next morning the traps were found pushed full of dirt. The mole did not use the tunnel nor disturb the traps on August 14, and the next morning each trap contained a short-tailed shrew. Thereafter, the runway fell into disuse.

Sorex cinereus cinereus Kerr. Cinereus shrew.—Average measurements of sixteen individuals of both sexes are: Total length, 97.1 (91–106); tail, 40.35 (36–49); hind foot, 11.5 (11–13).

In tabulating a series of eleven skulls, it was found that ten have the third and fourth unicuspids subequal, and one shows a gradual and regular decrease in size from unicuspid one through five, viewed in profile.

This species was taken at elevations ranging from 3500 to 4100 feet. Though most abundant in the forests, it was by no means confined there. Individuals were taken from dry brushy areas composed largely of *Crataegus* sp. and *Rhododendron cumberlandense*. Two males were caught simultaneously in a snap-back mouse trap set in a practically pure stand of *Dryopteris noveboracensis* at the edge of a small patch of *Crataegus* in the middle of a grassy field. Additional specimens were taken from a wet area where the dominant herbaceous plants were sedges and a species of *Chelone*.

Adult males with enlarged testes were taken between June 10 and July 16. A female with three embryos was collected August 10, 1939.

Of eighteen specimens, four were taken during daylight hours suggesting that these creatures are abroad at all hours. One was collected at 10:15 P.M. in the middle of a little-used road. When the light from the electric torch fell upon it, the shrew scurried beneath a few blades of grass and was easily collected by hand. Another apparently took up residence in our tent and was frequently seen moving deliberately over the floor.

Black Mountain is the only known locality for this species in the state of Kentucky (Barbour, 1941), although long known to occur in adjacent West Virginia, Virginia, and Tennessee.

Sorex fumeus fumeus Miller. Smoky shrew.—Measurements of 12 individuals of both sexes are: Total length, 117.2 (110–125); tail, 46.1 (41.5–50); hind foot, 13.2 (12–15).

Specimens were taken at elevations ranging from 2300 to 4000 feet. Eleven were taken from Harlan County, Kentucky, and two from Wise County, Virginia. Although apparently inhabiting a greater range of elevation than *Sorex c. cinereus*, this species appears to be less common. Specimens were taken from the following habitats: wet area, mixed mesophytic forest, dominant herbaceous plants, sedges and *Chelone*, north slope, elevation 4000 feet; dry *Tilia-Liriodendron-Robinia-Acer* woods, south slope, elevation 3200 feet; dry oak-hickory second growth, south slope, elevation 2700 feet; moist woods, beech-birch-maple understory of *Hamamelis* and *Laportea*, north slope, elevation 2700 feet; dry *Robinia-Sassafras-Quercus* woods, south slope, elevation 2600 feet; moist birch thicket at edge of stream, elevation 2300 feet. In every case the specimens were caught from runways, either under the leaf mould or under the shelter of a log or stone. No individuals were taken in an area that might be called brushland or open.

Males in breeding condition were collected on June 17 and July 7. A lactating female was collected June 17. No individual was collected during midday, indicating perhaps that this species is more decidedly nocturnal than the preceding. Hamilton (1940) has shown, however, that this shrew is active at all hours.

This species has been recorded previously from only two localities in Kentucky. Bailey (1933) took a series from Mammoth Cave, and Welter and Sollberger (1939) collected one specimen from near Morehead, Rowan County.

Handley and Patton (1947) have previously reported this species from Wise County, Virginia.

Blarina brevicauda churchi Bole and Moulthrop. Short-tailed shrew.—Measurements of 25 adults of both sexes are: Total length, 121.1 (112–130); tail, 25 (22–28); hind foot, 14.7 (11–16).

The Black Mountain specimens most nearly approach *Blarina b. churchi* in total length, but are longer. The tail averages shorter than in *churchi*. They are closest to *churchi* in length of the hind foot, and intermediate between *churchi* and *kirtlandi* in the character of the fifth unicuspid and the size of the foramen magnum.

This species was one of the most widespread of any collected. Individuals were taken at elevations varying from 2200 to 4150 feet. Woodland habitats ranged from the dryest oak-hickory associations to the damp, dark coves in virgin beech-birch-maple woodlands. Several individuals were collected from grassy fields where the tallest vegetation for yards was clumps of *Osmunda cinnamomea*.

Adult males in breeding condition were collected from June 8 to August 23. Lactating females were collected from June 27 to July 16. Individuals were taken at almost all hours of the day and night. They were often seen scurrying over the dead leaves during the daytime, but seemed to be more active at night. Specimens were caught on the surface of the ground as often as in runways. Runways made by *Parascalops* were often utilized.

On several occasions, a *Blarina* was caught in the same trap that had held the partially eaten carcass of a mouse the previous morning. This is the first record for this shrew in Kentucky. Handley and Patton (1947) had previously taken a series from Virginia, in Washington and Smyth counties.

Natives of the region are familiar with *Blarina*, and refer to them as "blue moles."

Myotis lucifugus lucifugus (LeConte). Little brown bat.—This species is represented by two specimens collected on July 7 and 15, 1948, as they flew over a residential section of Lynch at dusk.

Myotis subulatus leibi (Audubon and Bachman). Least brown bat.—One specimen was found on a road at an elevation of 3750 feet.

Pipistrellus subflavus subflavus (F. Cuvier). Pipistrelle.—Known from a single specimen collected July 31, 1939, from a group of bats flying over a pasture some four miles east of the town of Harlan.

Pipistrellus subflavus obscurus. Miller. Pipistrelle.—Known from two specimens collected within the corporate limits of Lynch.

No individuals were observed at an elevation greater than 2200 feet. As these little bats were often seen in the valleys, it is assumed that they are largely confined there.

This is apparently the first record of the occurrence of this bat from Kentucky, although Handley and Patton (1947) mention a specimen from nearby Giles County, Virginia.

Eptesicus fuscus fuscus (Peale and Beauvois). Big brown bat.—Specimens were collected from 1800, 1900, and 4100 feet elevation. Although present at the very summit of the mountain, this species was most often seen in the valleys. Microscopic examination of the cauda epidiymis of three adult males collected July 30, 1948, showed no viable spermatozoa. Two specimens were collected from the attic of a house in Lynch. Apparently several bats had previously roosted there, as there were several areas up to the size of a man's hand on the ceiling that were stained black. One resident told of removing 52 bats from his attic one day during the summer of 1947, and another told of collecting "a half-bushel."

Shortly before dark the bats emerge and fly about over the town. So common are they that the residents derive great sport from shooting them as they fly up and down the narrow valleys. Of the bats thus shot, approximately four out of five are of this species, the remainder principally pipistrelles.

Lasiurus borealis borealis (Müller). Red bat.—Known positively from a single specimen killed in a building in Lynch. At 11:00 P.M. on the night of June 14, a bat, thought to be of this species, was observed flying over the road at about the 3700-foot contour. A spotlight on the car was played on the bat several times and the distinctive color was quite apparent.

Procyon lotor lotor (Linnaeus). Raccoon.—Although no raccoons were collected, they are

apparently fairly common on Black Mountain. On several occasions areas were seen where the animals had dug crayfish from the mud along the small spring runs about the summit of the mountain. On one occasion clear tracks were seen. Natives spoke of "coon dens" in the Highsplint Coal Seam, but considerable trapping and two all-night hunts with dogs failed to produce any specimens. Residents of the area spoke of occasionally seeing raccoons abroad by day.

On purely geographical grounds, the raccoon of Black Mountain is assigned to this subspecies.

Mustela frenata noveboracensis (Emmons). Long-tailed weasel.—Two individuals were collected at elevations of 2750 and 3500 feet, respectively. None were observed at other elevations, but natives spoke of seeing them in the valleys and at the summit of the mountain.

Neither of the males (collected June 25 and July 9, 1948) were in breeding condition. One of the specimens was shot about 3:00 P.M. on a log across a small stream in a dense beech-birch-maple forest. The other was collected at midday as it chased a chipmunk across a highway. The stomach of one of the specimens contained the remains of a smoky shrew; the other the remains of a nestling passerine bird.

Mustela vison vison Schreber. Mink.—A single specimen shot by a native about August 10, 1946, near Lynch is referred to this race.

Natives of the region report that the mink are fairly common about the water courses and damp coves of the mountain. They speak of occasionally catching a "black mink."

Urocyon cinereoargenteus cinereoargenteus (Schreber). Gray fox.—A skull of this species was found in the valley of Looney Creek at an elevation of about 2300 feet, and an adult female was found dead on a road at an elevation of 3000 feet. Scats and tracks were observed at elevations ranging from 3750 to 4150 feet. An adult female collected July 26, 1943, had enlarged mammae, but was not lactating.

The major items found in numerous scats were achenes of *Fragaria* and *Rubus* and the pits of *Prunus*. On one occasion cottontail remains were found.

Foxes were often heard barking in the immediate vicinity of our camp during the first half of June, 1948, but none were heard after June 16.

Foxes made a habit of traveling along the logging roads and trails of the area. On numerous occasions fresh tracks were found in the mud of the roads, and examination of almost any 50 yard stretch of little-used road revealed one or more scats.

Marmota monax monax (Linnaeus). Woodchuck.—Woodchucks are distributed throughout the area studied, from the lowest to the highest elevations. Three young were collected and an adult was seen at the very summit of the mountain. They seemed to show no habitat preference, as individuals were seen in open fields, brushy areas, and the densest woodland.

A female with enlarged mammae was collected May 12, 1940. On June 11, 1948, three young averaging 453 mm. (426–472) in total length were collected from runways in a brushy area of *Quercus-Prunus-Castanea* at the very summit of the mountain. These three animals were apparently litter mates.

Dens were found in situations varying from loose soil to rocky cliffs. As a general rule, however, the dens were located under a stump, a pile of logs, or a large rock. Woodchucks about the summit of the mountain exhibited decided nocturnal habits; one was collected at 9:30 P.M. and another at 2:00 A.M. In each case, the animal was chased into a burrow by dogs. Residents of the area reported that they frequently caught 'chucks at night.

Tamias striatus striatus (Linnaeus). Eastern chipmunk.—Average measurements of nine adults are: Total length, 237.4 (224–249); tail, 81.3 (71–89); hind foot, 35.2 (30–39).

Chipmunks were collected at elevations ranging from 2300 to 4100 feet. Although most often seen along the roads and edges of fields, they were sometimes observed in dense woodland.

Males in breeding condition were collected from June 10 to July 26. No obviously pregnant or lactating females were collected.

Along the highway over the mountain, chipmunks utilized crevices in the rocks as dens; elsewhere, dens were usually located under stumps or large rocks.

During June, 1948, individuals were often observed feeding on the fruits of *Fragaria virginiana*. In one case, an individual was observed in the top of a *Morus*, feeding on the fruits. Later in the season, *Rubus* fruits were utilized. During August, chipmunks fed extensively on the fruits of *Prunus serotina*. Individuals were observed to gather the fruits from the tree, sometimes clambering to the topmost branches. Two individuals were collected from wild black cherry trees; examination of the animals revealed the fleshy part of the fruit had been eaten while the pits were temporarily stored in the cheek pouches.

The only indication of predation on chipmunks observed was that by a weasel. In this case, the weasel was shot as it chased a chipmunk across the road.

Tamias s. striatus has previously been recorded from Kentucky by Bailey (1933) and Hamilton (1930). Welter and Sollberger (1939) list *fisheri* (identified by Remington Kellogg) from Rowan County, and Bole and Moulthrop (1942) list two *ohioensis* from Bath County.

Handley and Patton (1947) considered their *Tamias* from Wise County, Virginia, as *striatus*.

Sciurus carolinensis carolinensis Gmelin. Gray squirrel.—Two specimens were collected at an elevation of 4000 feet. An individual was observed in Wise County, Virginia, at an elevation of 2300 feet; another was observed at 3500 feet in Harlan County, Kentucky. According to the residents of the area, squirrels are much more common at the lower elevations.

The two individuals collected July 4, 1946, were feeding on the fruits of *Cornus florida*. Another individual was observed feeding on wild grapes. According to the natives, the squirrels feed largely on the fruits of hickory, cucumber (*Magnolia acuminata* and *M. fraseri*), mulberry, and dogwood trees. Squirrels are said to be especially fond of the fruits of *Pyrularia pubera*.

Sciurus c. leucotis has not been recorded from Kentucky, although it may well occur. Handley and Patton (1947) listed it from nearby areas of Virginia; Kellogg (1937) reported only *leucotis* from West Virginia; and Kellogg (1939a) listed it from Tennessee.

Glaucomys volans saturatus Howell. Southern flying squirrel.—A single juvenile male was taken on June 9, 1948. Although definitely intermediate between *volans* and *saturatus* the specimen appears more closely related to the latter. Natives spoke of seeing flying squirrels at night on the bare limbs of dead chestnut trees. This is the first record of the occurrence of the southern flying squirrel in Kentucky.

Reithrodontomys humulis humulis (Audubon and Bachman). Eastern harvest mouse.—Known from three specimens secured July 18, 1939, from the valley of the Poor Fork of the Cumberland River, some four miles above the town of Harlan. Two skulls were found and an adult male was collected in a clover field. On purely geographical grounds, the specimens are assigned to *humulis*. Specimens from Lexington and Rowan County are considered *humulis* by Welter and Sollberger (1939). Handley and Patton (1947) reported *humulis* from Wise County, Virginia.

Peromyscus maniculatus nubiterrae Rhoads. Deer mouse.—Average measurements of 33 adult males are: Total length, 180.6 (167–196); tail, 92.9 (85–106); hind foot, 21.45 (20–23). Eighteen adult females average: Total length, 185.8 (165–201); tail, 95.4 (82–105); hind foot, 21.2 (20–23).

Hamilton (1943) gives the measurements of a series of 18 adults in the United States National Museum from Lynch, Harlan County, Kentucky, taken at an elevation of 4000 feet as: Total length, 178 (164–198); tail, 89 (77–97); hind foot, 20.3 (19–22). These specimens must have come from near the summit of Black Mountain, as nowhere else in the vicinity of Lynch do the mountains rise to this elevation.

No *maniculatus* were collected at an elevation less than 3800 feet on the south side of the mountain. On the north side, however, the species ranged down to at least 2700 feet. A single juvenile was collected at this latter elevation. No adults were collected below 2900 feet. Of 73 animals taken, 67 were collected above 3000 feet, and only six were taken between 2700 and 3000 feet.

Kellogg (1939*a*) reported this species at 2700 feet elevation in Tennessee, and Komarek and Komarek (1938) reported it at 2500 feet in the Great Smokies.

In every instance, the Black Mountain specimens at the lower elevations were taken from dense forests of beech, birch, and maple. In such areas the forest floor remained quite cool and moist, even in the hottest, dryest part of summer.

Specimens taken above 3900 feet exhibited a much wider range of habitats. Individuals were taken from such divergent habitats as a patch of redtop and timothy near an old house site; sedges along a spring run through an open field; a relatively dry thicket of *Crataegus* and *Rhododendron cumberlandense*; a thicket made up almost exclusively of small *Betula*; second growth birch-maple-chestnut; and a patch of *Lysimachia quadrifolia*, as well as the mixed mesophytic forest.

Adult males in breeding condition were collected from June 9 through August 18. Females, with embryos as indicated, were collected on the following dates in 1948: June 9 (1 in right, 2 in left horn; 3 mm.), June 27 (3 right, 1 left; 1 mm.), June 28 (1 right, 3 left; 4 mm.), June 30 (1 right, 1 left; 9 mm.), July 21 (1 right, 2 left; 6 mm.), July 26 (1 right, 3 left; 4 mm.), August 13 (3 right, 1 left; 6 mm.). Lactating females were collected from June 16 through August 29.

In two instances, individuals were taken from the burrows of *Parascalops* and the runways of *Synaptomys*. Most often, the mice were taken from burrows, runways, or the surface of the litter of the forest floor about logs and stumps. One individual was taken from a three-inch ledge some fifteen feet up a vertical sandstone cliff; three individuals from the roof of our tent, and another from within the tent, and one or more mice were often heard scampering over the roof of the tent at night.

All our specimens were collected during the night. Individuals were seen several times during the day, but in every instance were started from a hole in a dead tree. In one case, two individuals were put out of a woodpecker hole about forty feet up in a dead chestnut tree.

This species is known to occur in Kentucky only about the summit of Big Black Mountain.

Natives of the region are quite familiar with the deer mouse, referring to it variously as a "woodrat," or "wood mouse." I was somewhat startled one day to hear an old native remark, as he watched me preparing skins, that these were the animals that "made the mice herds." Some discreet questioning revealed that the natives in former years, when chestnuts were abundant, raided the stores of these little creatures. According to this old fellow, the "herds" (hoards) were in hollow trees, and often amounted to half a bushel of chestnuts.

Peromyscus leucopus noveboracensis (Fischer), White footed mouse.—Average measurements of 37 adults of both sexes are: Total length, 172.7 (152–186); tail, 81 (63–97); hind foot, 21.8(20–23).

Komarek and Komarek (1938) comment on the difficulty of assigning specimens from the Great Smoky Mountains to either *leucopus* or *noveboracensis*. Specimens examined, from Black Mountain, are clearly *noveboracensis*.

In an effort to determine if any correlation exists between size and elevation, the Black Mountain specimens were grouped according to elevation and averages calculated. No significant correlation was found. Specimens from the lowest elevations average as large as those from the summit of the mountain.

The Komareks report that *leucopus* in the Great Smoky Mountains "probably ranges up to about 2500 feet." Kellogg (1937) states that in West Virginia "available records indicate that its vertical range stops at about 3000 feet." In Tennessee, Kellogg (1939*a*) lists one specimen from 3800 feet in Johnson County.

On Black Mountain, specimens were taken at elevations ranging from 1800 to 4150 feet. Of 47 individuals taken, 29 were collected below 2700 feet, and 18 above. No *maniculatus* was taken below 2700 feet. Both species occupy the same habitat about the summit of the mountain, but as the elevation is decreased *maniculatus* becomes less abundant and *leucopus* more abundant. Only the latter is found at elevations below 2700 feet.

No mice were taken from open areas about the summit of the mountain, but individuals were taken from all stages of the beech-birch-maple habitat, from virgin timber to recently

cutover areas. Three specimens were taken at 4150 feet altitude from a log pile in a *Quercus-Castanea-Prunus* thicket. On the lower slopes, *leucopus* was most often found in the oak-chestnut-hickory association, with a few individuals found in other habitats.

Males in breeding condition were collected from June 8 to August 26. Lactating females were taken from June 17 to August 15. A female collected August 18 carried four four-millimeter embryos, two in each horn of the uterus.

Peromyscus nuttalli nuttalli (Harlan). Golden mouse.—It is difficult to assign the single specimen to a specific race. Comparison of the skull with a series of *aureolus* from Georgia reveals no apparent difference in molar width as mentioned by Osgood (1909). Comparison with a series of *lewisi* from Seward Forest, Triplett, Virginia, reveals no apparent differences in color. On purely geographical grounds, the specimen is assigned to *nuttalli*.

One individual was seen at an elevation of 2300 feet on the south slope of Black Mountain in Wise County, Virginia. A family group was seen that had been found by a resident at an elevation of 2700 feet near Lynch. The specimen taken was collected from the valley of the Poor Fork of the Cumberland River about four miles above the town of Harlan.

From the data obtained, it appears that the golden mice of the area studied are confined to the valleys and lower slopes. Mice were observed from three separate areas, but in each case the habitat was much the same. The areas in each case were brush-covered, and *Smilax* was much in evidence, vining out to the tops of the brush. I have collected golden mice in other areas of eastern Kentucky and have noted that *Smilax* is always one of the dominant plants of the habitat.

Two nests of the golden mouse were observed August 12, 1948, at an elevation of 2300 feet in Wise County, Virginia. The nests were five and fourteen feet from the ground, respectively. The nests were globular, about five inches in diameter. Each nest was placed in a tangle of *Smilax*. Structurally, the nests were quite simple, although well made. In each case, a platform of dead leaves had been built and the nest constructed thereon. The inner bark of *Tilia* was used exclusively; coarsely shredded bark on the outside, and progressively finer strips on the inside. The lining of the nests was of finely shredded strips, varying from some 2 to 6 inches in length. The entrance to the nests was placed on one side, and measured about three-quarters of an inch in diameter. One of the nests was empty; the other contained a mouse that jumped out and promptly disappeared in a burrow in the ground.

On August 18, 1948, I saw an adult female and three young that had been caught on July 28. According to the boy who took them, he was cutting weeds along the edge of a garden (in a cleared spot on a brushy hillside) when he saw a mouse jump from a nest about two feet from the ground in a tangle of greenbrier (*Smilax*). He tore open the nest and found three young, with unopened eyes. Within five minutes, the adult returned to the nest site and was caught by hand. The mice were kept in a wood and wire cage, and fed table scraps. When I first saw the mice they had been in captivity three weeks. When frightened from the nest of cotton, the mother ran the length of the cage (about three feet) dragging the half-grown young which were clinging tightly to her nipples. Although still nursing, the young at this time were taking some solid food. The boy had become so attached to his "pets" that he refused to part with any of them.

Natives of the region are apparently unfamiliar with these animals. The "pets" mentioned above created quite a bit of interest in Lynch, as very few people had seen such mice.

Neotoma magister Baird. Allegheny wood rat.—An adult male found dead on the highway on July 5, 1948, at an elevation of 2400 feet on Big Black Mountain, had considerably enlarged testes. A lactating female was taken on August 24, 1948, at an elevation of 2300 feet on Pine Mountain, near the town of Cumberland, Kentucky.

On Pine Mountain, signs of the animal were much in evidence about the numerous sandstone cliffs and ledges. The specimen taken there was collected from a ledge on a cliff no more than a hundred yards from a mountain cabin. The man who lived in the cabin had no inkling of the existence of woodrats, although he cultivated a garden to the base of the cliff. Piles of corn stalks and other debris collected by the woodrats were much in evidence along a four-foot ledge five feet up from the base of the cliff.

Some of the residents are familiar with these animals, and have mentioned seeing their tracks in light snow.

Synaptomys cooperi stonei Rhoads. Bog lemming.—Five adults were collected from three restricted areas in a single large clearing at about 3900 feet elevation.

Males in breeding condition were collected on June 10 and August 28, 1946. No obviously pregnant or lactating females were taken.

On August 8, 1939, a colony was found near the middle of a pasture, and three adults were collected therefrom. An uninhabited nest, presumably of this species, was a globular structure about eight inches in diameter, built solely of grass. The well-hidden nest had a prominent runway.

In 1948 the site of this now deserted colony was largely grown up to *Potentilla simplex*, *Fragaria virginiana*, and *Lysimachia quadrifolia*. A colony was found some 150 yards away among the grasses and *Chelone* below a small spring. A second colony was discovered in 1948 in a patch of redtop and timothy near an old house site.

At each colony, runways and piles of cuttings were in evidence. No other species were collected from the runways except in the area below the spring, where *Peromyscus* and *Napaeozapus* were taken.

Clethrionomys gapperi maurus Kellogg. Red-backed vole.—Average measurements of 35 adult males are: Total length, 144.7 (125–158); tail, 39.3 (33–49); hind foot, 20 (18.5–21). Eighteen adult females average: Total length, 145.8 (133–157); tail, 38.6 (33–45); hind foot, 19.9 (18–21). All of the above specimens came from within five miles of the type locality.

Kellogg (1939*b*) gives the measurements of six adult female topotypes, including the type as: Total length, 153.8 (147–172); tail, 37.8 (36–41); hind foot, 19.5 (19–20). Two adult male topotypes are, respectively: Total length, 155, 146; tail, 42, 35; hind foot, 20. 19.

Specimens were collected as low as 2250 feet on the north side of the mountain, and down to 2300 feet on the south side, in Wise County, Virginia. Most of our specimens came from about the summit of the mountain.

Males in breeding condition were collected from June 8 to July 28, lactating females from June 8 to July 3, 1948, and females with embryos as follows: June 8 (2 in right horn, 2 in left horn; 8 mm.), June 16 (3 right, 1 left; 5 mm.), June 30 (1 right 2 left; 14 mm.), July 2 (1 right, 2 left; 16 mm.), July 21 (3 right; 7 mm.), August 28 (1 right, 2 left; 3 mm.). Presumably the young average three or four and are produced through June to September.

Several specimens were captured during the daylight hours and individuals were occasionally seen scampering about over the forest floor by day.

These voles were most often found along large logs and in rock piles in damp woodlands, but were not restricted to that habitat. Individuals were taken in a very wet situation where the dominant plants were sedges and *Chelone*; in dry areas where the dominant plants were *Crataegus* and *Rhododendron cumberlandense*; in dry oak-hickory associations; and in dry rocky areas where the vegetation was a practically pure stand of *Liriodendron*.

Individuals were taken from the surface of the leaf mold; from runways under rocks and logs; from burrows four inches beneath the surface of the leaf mold, and in two instances from the opening of a burrow in the base of a dead standing tree.

Kellogg (1939*b*) implied arboreal habits of these voles. Although I nailed numerous traps to the trunks of standing trees and caught several white-footed mice, no redbacks were taken in such traps.

The remains of redbacks were found in the stomachs of four of eight rattlesnakes (*Crotalus horridus horridus*) examined.

Pitymys pinetorum scalopsoides (Audubon and Bachman). Pine vole.—Remains of a pine vole were taken from the stomach of a pilot black snake collected July 8, 1948, at an elevation of 1850 feet. The specimen is assigned to the northern race on geographical evidence.

Ondatra zibethica zibethica (Linnaeus). Muskrat.—In mid-June, 1948, a muskrat was uncovered by a bulldozer from the bank of Looney Creek in the corporate limits of Lynch. Examination of the skull indicates the subspecies *zibethica*. Residents informed me that muskrats are fairly common in the larger streams of the area.

Mus musculus musculus Linnaeus. House mouse.—Two specimens of this cosmopolitan pest were collected. One was taken from a residence in Lynch; the other from a maple-birch second growth forest at an elevation of 2600 feet. The latter specimen was taken a half mile from the nearest human habitation.

Rattus norvegicus (Berkenhout). Norway rat. One was collected July 7, 1948, at an elevation of 1800 feet at a pig pen on the outskirts of Lynch; another was collected on August 10, 1939, from underneath the floor of a cabin at 4000 feet near the summit of the mountain. This cabin was burned in 1947, and no rats were collected anywhere on the mountain in 1948.

Natives apparently differentiate between *Rattus* and *Neotoma*; the former are referred to as "gopher rats," "gophers," or "mine rats;" *Neotoma* are referred to as "cliff rats" or "woodrats." The name "mine rats" for *Rattus* apparently arose from the fact that these rats reportedly enter the numerous mines of the region and feed on scraps from the miners' lunch boxes.

Napaeozapus insignis roanensis (Preble). Woodland jumping mouse.—Average measurements of eight adults are: Total length, 215 (207–227); tail, 130.25 (115–140); hind foot, 28.9 (28–30).

Individuals were taken at elevations ranging from 2250 to 4000 feet. No specimens were taken on the south side of the mountain. Jumping mice were taken from the following habitats: *Rhododendron maximum* thicket, edge of running stream; birch-maple second growth, abundant growth of ferns on forest floor (largely *Athyrium angustum* and *Dryopteris noveboracensis*); very dense birch-maple thicket; wet area along spring run through an open field, dominant plants, sedges, grasses, and a species of *Chelone*.

Males in breeding condition were collected June 9 and 10, 1948. A female with four ten-millimeter embryos was taken on August 28, and a lactating female was collected on June 9, 1948. No individuals were taken during the daylight hours, nor were any observed.

Four specimens were taken in traps set on the surface of the leaf mold; two individuals were caught at the entrance of a burrow under a large stone; and two individuals were taken from runways that had previously yielded *Peromyscus*.

This species has previously been recorded from Kentucky only once, and the single specimen was taken at the summit of Black Mountain (Barbour, 1941). This specimen is included in the above report. Natives of the region are unfamiliar with this animal, and expressed surprise that such creatures lived in the area.

Sylvilagus floridanus mearnsi (Allen). Cottontail.—Specimens were collected at elevations ranging from 2700 to 4100 feet. Individuals were observed at elevations ranging from 1800 feet to the summit of the mountain.

An adult male in breeding condition was collected July 1, 1948. A lactating female, taken June 18, contained five large embryos.

Rabbits are fairly common about the summit of the mountain in cutover areas and open fields. Tracks were frequently seen in muddy places along the roads, and individuals were often observed late in the afternoon and early in the morning feeding along the roadsides.

The only evidence of predation on the cottontail is that treated previously under *Urocyon*.

This race is apparently the common cottontail of eastern Kentucky. Hamilton (1930) and Welter and Sollberger (1939) record this race from eastern Kentucky. Handley and Patton (1947) record only *mearnsi* from adjacent sections of Virginia.

Sylvilagus transitionalis (Bangs). New England cottontail.—One specimen was taken at an elevation of 3900 feet from an "ivy patch" composed largely of *Kalmia* and *Vaccinium* with a few deciduous trees and shrubs. According to the natives, these "red rabbits" are found only in such "ivy patches."

This is the first record of the occurrence of this species in Kentucky. Nelson (1909) lists specimens from Virginia, West Virginia, North Carolina, and Georgia, and Kellogg (1939*a*) records the species from Tennessee.

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GENERAL NOTES

NOTES ON AGE DETERMINATION IN SQUIRRELS

As in other species, age ratios of squirrels are important data in the study of population characteristics and fluctuations. Age criteria and age ratio collection methods, of course, are essential factors.

Allen (Mich. Dept. Cons., Game Div., Publ. 100, 1943) has described age differences in the fox squirrel (*Sciurus niger*) which have been confirmed and extended also to the gray squirrel (*S. carolinensis*) by Brown and Yeager (Ill. Nat. Hist. Surv., Bull. 23: 449-536, 1945). These are largely age criteria which involve the external sex structures—the teats in females and the scrotum in males. Brown and Yeager provide supplementary criteria concerning the development of the Cowper's gland in males, the size of the uterus in females, and characteristics of body length, tail shape, and color of the tips of the guard hairs in both sexes. Despite this knowledge, however, as stated by Brown and Yeager (*ibid.:* 460), "no simple, yet infallible, method of determining age classes in fox and gray squirrels has been reported."

PLATE I

X-ray images of gray squirrel forefeet. A. Juvenile probably of the second litter, showing wide separation between epiphyses and diaphyses of radius and ulna. B and C. Juveniles probably of the first litter showing distinct but narrow separation of epiphyses and diaphyses. D. Adult squirrel with completely fused bones.

During a study of age criteria and their uses in many species, while the author was with the Ohio Cooperative Wildlife Research Unit, 18 gray and 37 fox squirrels were examined near Mercer, Pennsylvania. In none of these specimens did there seem to be any doubt as to their identifications as juveniles of the year or as older adults, according to the condition of the teats or scrota.

In an attempt to discover age recognition marks, on a part of a squirrel's body, which could be easily collected and sent through the mail, six gray squirrels were collected at Columbus, Ohio, from October 16 to November 21, 1947. These specimens comprised three adult females, two immature males, and an immature female, as judged from characteristics of the teats and scrota. X-ray examination disclosed that in the young animals the distal epiphyses of the radius and ulna were either distinctly separated from the diaphyses of these bones (Pl. IA) or showed a distinct line of fusion (Pl. IB and C). In the adults, the epiphyses were completely fused with the shafts of the bones (Pl. ID). It is believed, from the characteristics of the scrota of the two males, that the open epiphyseal condition (Pl.

IA) probably is a characteristic of summer-born young, while partial ossification (Pl. IB and C) may be typical of spring-born juveniles. Should further investigation prove these differences to be as readily recognizable as they are in cottontails (Petrides, Amer. Mid. Nat., in press), then paw collections may permit the recognition of adults and the estimation of birth dates in juveniles.

Especially in view of the small number of specimens available for study, no definite assertions that this technique is an infallible one can be made, nor can final date for the use of the method be given now, but it seems rather certain that it would be useful in determining young : adult ratios at least through October. It is offered here so that it may be tested further by other interested workers.

This method has the particular advantage that it lends itself to widespread sampling by mail. Amputated paws can be sent by co-operators to a collection point where they can be examined by X-ray at a much lower cost than would be required for a comparable field survey. Where reliable co-operators are available, sex ratios may be simultaneously collected by requesting right paws from males and left ones from females, or vice versa. Hunters must be warned to supply a generous portion of the bones of the foreleg as well as the foot itself.

It is estimated that about 100 squirrel feet can be placed on an 8″ x 10″ X-ray plate. If necessary, the toes can be removed to permit further crowding. Specimens should not be stored any longer than necessary before being X-rayed. Extreme desiccation increases the density of the specimen and may limit the accuracy of age determination. Two weeks or so, however, is believed not to be too long to hold such specimens. Alcoholic preservation may permit longer storage.—George A. Petrides, *Departments of Zoology and Fisheries and Wildlife, Michigan State College, East Lansing, Michigan.* *Received June 20, 1949.*

PLURAL CANINES IN ELK

In the course of authorized reduction of the elk (*Cervus canadensis canadensis*) herd in Rocky Mountain National Park, Colorado, December 1949, the senior author noticed the unusual occurrence of plural canines in an elk. This animal was a female estimated to be four or five years old; she was pregnant and on the basis of body fat judged to be in very good physical condition. The collection date was December 12, 1949.

PLATE I

Skull of 4- or 5-year old, female elk showing double canines. Animal taken in control operations in Rocky Mountain National Park, Colorado, December, 1949.

To permit further observation, the head of the animal (which had been shot a few hours before) was delivered to the junior author, who had it prepared as a museum specimen. Examination subsequently proved the occurrence of two separate upper canines on each side; extraction showed that the teeth were not joined at the root. After examination, all four teeth were cemented carefully, without injury, into their original sockets. The specimen was retained by the Colorado Cooperative Wildlife Research Unit, Colorado A & M College, Fort Collins.

Cursory examination of the literature, and extensive inquiry among biologists having much experience with elk, yielded no other recorded instance of double canines in the genus *Cervus*. Warren J. Allred told the junior writer of seeing a burred, and apparently plural, canine in a Wyoming elk, but extraction disclosed a dichotomous tooth with a single root system.

The writers express their appreciation to Robert S. Elliott, Colorado Game and Fish Department, who assisted with the specimen in the field; to C. N. Feast, II. for preparatory work in the laboratory; and to J. Barton Herschler, Wildlife Ranger, Rocky Mountain National Park, for courtesies relative to collection and consignment.—ROBERT G. KINGHORN AND LEE E. YEAGER, *Colorado Game and Fish Department, Denver and, Colorado Cooperative Wildlife Research Unit, Fort Collins.* *Received May 8, 1950.*

FLUCTUATIONS IN POPULATION OF SMALL MAMMALS IN UTAH

During the summers of 1946, 1947, and 1948, the writer spent considerable time studying small mammals in the field in eastern Utah and somewhat less in other parts of the state. While the nature of the work precluded repeated sampling of areas, sufficient data on population numbers of small mammals, both from trap yields and sight observations, were accumulated to warrant making them a matter of record.

TABLE 1.—*Trap yields for 1946, 1947, and 1948 at Rock Canyon Corral, Utah*

SPECIES	1946 (600 TRAP NIGHTS)	1947 (622 TRAP NIGHTS)	1948 (30 TRAP NIGHTS)
Citellus leucurus cinnamomeus	—	1	—
Eutamias quadrivittatus hopiensis	—	1	2
Perognathus apache caryi	—	1	—
Dipodomys ordi sanrafaeli	3	11	1
Onychomys leucogaster pallescens	—	6	—
Peromyscus crinitus auripectus	—	2	—
Peromyscus maniculatus osgoodi	2	83	10
Peromyscus truei truei	—	1	—
Neotoma lepida sanrafaeli	—	5	4
TOTAL	5	111	17
Percentage of yield	.8	17.8	56.6

Rabbit hunting, principally for black-tailed jack rabbits, is a popular sport in the winter months in Utah. During the winter of 1946–1947, rabbit populations in the Great Basin were so low that few hunters succeeded in obtaining any animals. In the following winter, hunters had considerable success in southern Idaho and extreme northern Utah, although rabbits were still scarce elsewhere in the latter state. By the following winter, 1947–1948, numbers of jack rabbits and cottontails had increased greatly, even in the southern part of Utah—so much so, in fact, that the animals had become a serious nuisance in local areas. At a locality two miles south of Torrey, Wayne County, in July, 1948, in less than ten minutes 23 cottontails were flushed from cover along a stream bank in a distance of 50 yards. In this same vicinity all thickets were virtually honeycombed with runways and even the more

unpalatable species of vegetation showed a definite browse line. In the first week of August in 1946, 1947, and 1948, at a locality eleven miles north of Gunnison, Sanpete County, roadside counts were made of the number of rabbits seen in the light from the head lamps of the automobile that I drove. The transect was one mile long and the counts were made shortly after midnight. Each year the weather conditions were comparable—clear, warm, and windless. Results were as follows: *Lepus californicus deserticola*, 1946, none; 1947, alive, 5, dead, 2; 1948, alive, 49, dead, 18. *Sylvilagus* sp., 1946, none; 1947, alive, 1; 1948, alive, 7, dead, 7.

In spite of the obvious lack of precise areal and ecological comparison, the results are impressively different for the three years.

At another locality, Rock Canyon Corral, five miles south of and one mile east of Valley City, Grand County, some comparative trap yields for the three successive years are available. In each year the trapping at this locality was done in the middle of June. Trap yields are shown in Table 1. The smaller number of kinds in 1948 is probably due to the smaller number of traps.

During the three summers' work, woodrats, *Neotoma lepida*, were especially sought. Only two specimens were obtained in 1946 at all localities visited; six were obtained in 1947; and in 1948 they were common in the eastern part of the state wherever there was suitable habitat.

The high point in trap yield was reached in the middle of August, 1948, at Browns Corral on the East Tavaputs Plateau, Uintah County, some twenty miles south of Ouray. Browns Corral is a sheep-shearing establishment, and, as a consequence, the vegetation in the vicinity was unusually heavily over-grazed. In spite of the inhospitable environment, 206 snap traps were set out in the immediate vicinity of and within the corrals themselves. Next morning the traps contained a total of 186 *Peromyscus maniculatus osgoodi*, 2 *Dipodomys ordi uintensis*, 2 *Perognathus apache caryi*, and 2 *Lagurus curtatus levidensis*. Significantly, 144 of the *Peromyscus* were half-grown young. Each of six traps contained two animals, and a seventh held three. Not only was the bait gone from most of the traps, but the wooden part of the treadles of most of the traps had been gnawed in an attempt to obtain the last vestige of bait. Most of this gnawing probably was done by untrapped mice after the traps had been sprung. Continued trapping on the two following nights in essentially the same places showed no appreciable diminution of yield nor change in percentages of yield for each species. So numerous were the mice that sleep for the collectors anywhere but in a truck was an impossibility. Response of the birds of prey to this unusual population was most evident in short-eared owls. Eighteen were counted at one time by the light of a full moon in a clearing of less than two acres in extent. Although no records of trap yield are available from this same locality for other years, no data obtained from essentially similar habitats in the same general area even closely approach those of 1948.

It is also worthy of note that *Citellus townsendi mollis*, after an apparent absence for a number of years, was again taken in Salt Lake Valley in 1947. Further, *Zapus princeps cinereus*, *Microtus richardsoni macropus*, and *Microtus pennsylvanicus modestus* were common in localized areas in 1947 and 1948 where, to judge by trap yields, they had been scarce for a number of years. In the same years, however, the bushy-tailed woodrats, *Neotoma cinerea*, continued to be scarce in their haunts of former years.

Although no definitive data are available bearing on the point, the writer is under the impression that during the periods covered by these observations, population changes in montane species of small mammals were far less marked than in the lowland kinds.—Keith R. Kelson. *Museum of Natural History, University of Kansas, Lawrence, Kansas.* *Received May 8, 1950.*

EASTERN MOLES EATEN BY COTTONMOUTH AND GRAY FOX

Relatively few instances of natural predation on the eastern mole, *Scalopus aquaticus*, are on record. An incomplete check of the literature revealed that eastern moles are preyed on sparingly by barn owls (Davis, Jour. Mamm., 19: 499–500, 1938), horned owls (Errington, Hamerstrom, and Hamerstrom, Iowa Agric. Exp. Sta. Res. Bull., 227: 759–849, 1940), coyote

(Sperry, Wildlife, Res. Bull., 4: 44, 1941), and red fox (Scott, Ecol. Monog., 13: 427–479, 1943, and Iowa Agric. Exp. Sta. Res. Bull., 353: 427–487, 1947).

To this list of predator species I can add the gray fox (*Urocyon cinereoargenteus*) and the cottonmouth (*Agkistrodon piscivorus*). A fox that had eaten a mole was trapped January 18, 1948, in Robertson County, Texas, within the range of *S. a. cryptus* Davis. A cottonmouth, captured near Douglassville, Cass County, Texas, April 23, 1950, within the range of *S. a. pulcher* Jackson, contained an adult mole in its stomach.—W. B. Davis, *Department of Wildlife Management, College Station, Texas. Received May 6, 1950.*

THE NEST OF A SHORT-TAILED SHREW

The nest of a short-tailed shrew, *Blarina brevicauda kirtlandi*, was found near Blacklick, Franklin County, Ohio, on October 11, 1949. It contained an adult female and three young female shrews.

The nest and the shrews were found immediately after a scraper had cut through a fencerow mound. The nest was scattered and the female and young were stunned by the impact. The nest position was between the surface and the nine-inch depth of the cut. Nesting material consisted only of dried leaves of *Crataegus*. The shrubs were growing several feet away in the fencerow.

The lactating adult female weighed 13.5 grams and the fully-furred young weighed 8.0, 9.1, and 9.1 grams, respectively. Teeth were not protruding through the gums of the young, but were well formed beneath them. The young regained consciousness after a short period, but were quite helpless. Apparently they were still dependent upon maternal care.—Julian L. Dusi, *Dept. of Zoology and Entomology, Alabama Polytechnic Institute, Auburn, Alabama. Received August 21, 1950.*

MOTHER AND YOUNG OF *SOREX CINEREUS FONTENALIS* IN CAPTIVITY

On April 19, 1950, I turned over a stump lying in a dry field in Bethesda, Maryland, and saw a long-tailed shrew run from a bulky nest of dry leaves and grass. The shrew scurried off, then returned, so that I was able to capture it. In the nest were six pink, naked, active young ones about one-half inch in length. Their eyes appeared open, but might have been covered by a thin transparent membrane of skin. Mother and young were placed in a large vivarium. This was darkened with a blanket and contained a small box hideout. Observations were limited in order to disturb the mother as little as possible. The young lay on top of the nest rather than in it as originally found. Although the mother shrew drew a few pieces of leaves over the young, she showed little ability to reconstruct the nest. She curled over the young most of the time and was observed nursing them. When frightened off on one occasion, a single young, adhering to her teat, was dragged four inches away. The mother quickly returned, picked up the young one in her mouth, and replaced it in the nest. When running about the vivarium, she fed readily on raw liver and ate the brains from a dead mouse. Thirty-six hours after capture the young turned blue and died. Possibly they were not sufficiently warm and dry, as they were not covered over as originally found. The young ones were preserved in alcohol. After their removal, the mother never ceased searching for them. She kept pulling the nest apart and tunneling in and out of the wreckage until found dead six hours later in the place where the young had lain. Mother and young were given to the Smithsonian Institution, where the identification was made.

It seems questionable whether these shrews build their own nests, considering that this one showed little ability at reconstructing her nest, which was indistinguishable from that built by meadow mice.—Lawrence Kilham, *Bethesda, Md. Received May 25, 1950.*

BREEDING OF *CRYPTOTIS PARVA* IN TEXAS

A male, female, and four young *Cryptotis parva* were taken in Brazos County, Texas, on February 25, 1950, from a nest located within 25 yards of the Brazos River on a sand bank about thirty feet above the water. Several species of large hardwoods lined the river bank, and dense stands of Bermuda grass covered the ground in the immediate area. I overturned

a piece of tin about two feet square, exposing the runways and nest. The main tunnel was about 18 inches in length and 2½ inches in depth. The nest was about one-half inch deeper than the tunnels, three inches in diameter, and its sides and bottom were lined with grass. The young shrews averaged 48 mm. in total length.

On March 18, 1950, I collected a blotched king snake, *Lampropeltis calligaster*, from a prairie pasture in Brazos County. Upon evisceration, a slightly digested infant shrew was discovered in the snake's stomach. It was about the same size as the four taken in the nest mentioned above, and was identified by Dr. W. B. Davis as *Cryptotis parva*. On the basis of Hamilton's data (Jour. Mamm., 25: 1–7, 1944), the age of these young shrews was estimated at about two weeks. These records definitely establish the breeding of *Cryptotis*, in this part of its range, at least one month earlier than has heretofore been recorded.—Tom Hunt, *Department of Wildlife Management, College Station, Texas. Received May 6, 1950.*

BREEDING OF THE OCELOT IN TEXAS

Reproductive information on the ocelot (*Felis pardalis*) in Texas is relatively scarce. Bailey (N. A. Fauna 25, 1905) and Seton (Lives of Game Animals, New York, 1925) both report the observations of a Mr. Howard Lacey of Kerrville. In 1903, Mr. Lacey wrote that he had recovered two kittens, several weeks old, from a cave after killing the mother. This occurred in November as did another capture of a female ocelot with two well-developed embryos.

On April 14, 1950, B. O. Thomas caught a female ocelot which contained two fetuses of large size. The animal was captured in heavy mesquite brush on the Norias Division of the King Ranch, Kenedy County, about 70 miles north of Brownsville, Texas. Ocelots are uncommon, but not extremely rare in that vicinity.

The two kittens must have been within a day or two of parturition and displayed the well-marked coat pattern of the species. Both were females. Their standard measurements in millemeters were 230–55–35–10 and 248–55–33–9. The three specimens mentioned are preserved in the collection of the Texas Cooperative Wildlife Unit at Texas A & M College.

The date of this record tends to confirm Seton's suspicions, based only on the warm climate of their usual range, that the young may be born throughout the year.—George A. Petrides, B. O. Thomas and Richard B. Davis, *Departments of Zoology and Fisheries and Wildlife, Michigan State College, East Lansing, Michigan, U. S. Fish and Wildlife Service, Norias, Texas, and Texas Cooperative Wildlife Unit, College Station, Texas. Received August 4, 1950.*

A RECORD OF MOOSE SPEED

While driving along a dirt road in northern Jackson Hole, Wyoming, during July, 1948, the writer and a companion, Mr. Norman Negus, encountered a moose calf (*Alces americana*) by the roadside. On each side of the road was a slanting cattle fence about five feet high. We had driven by the calf before we noticed it and as we turned around and went back to look at it the cow, which had been standing in a willow thicket on the other side of the fence, jumped the fence onto the road to join her calf. As we drove nearer, the calf became frightened and began to run down the road ahead of the car and was joined by the cow. The calf tried several times, but was unable in its frightened state, to get through or to clamber over the fence. While both of them were in headlong flight the cow leaped over the fence several times with no apparent effort. During the chase we clocked the cow at 22 miles per hour, and then the calf tired and dropped behind the car and we also passed its mother. The pair trotted back down the road. After stopping and taking several photographs we left them to their own devices.—James S. Findley, *2645 Fairmount Blvd., Cleveland 6, Ohio. Received July 1, 1950.*

TASMANIAN SPINY ANTEATER WITHSTANDS LOW TEMPERATURE

While doing field work in Tasmania in late October, 1949, I occasionally observed spiny anteaters (echidnas), *Tachyglossus setosus*, ambling across the highway. Three of them were

captured alive and shipped by express to my associate, Henry Wichers, and to P. C. R. Boswell, Senior Preparator at the National Museum of Victoria, Melbourne, Australia. The specimens arrived on Saturday when it was inconvenient to care for them, so they were chloroformed and placed in a deep freeze, to be cared for later. The next Monday the surprised preparators found that one echidna had recovered and was apparently quite happy. The other two were frozen solidly, as was to be expected in a temperature 42 degrees below freezing.—ALFRED M. BAILEY, *Denver Museum of Natural History, Denver, Colorado. Received August 24, 1950.*

A TAME RED FOX CUB

During part of July, 1948, the writer was engaged in field work at Togwotee Pass, Teton County, Wyoming. On July 14, a den of red foxes (*Vulpes fulva macroura*) was discovered on a dirt and rock bank along a dirt road through spruce-fir forest. The den was located at night when three young were seen in the automobile headlights. They had evidently just left the den and were not afterwards seen to return. Immediately an attempt was launched to photograph the young with the use of flash equipment. At first a great deal of stealth and cunning was employed, but it soon became evident that one of the cubs was so fearless that it was not necessary for the photographer to conceal himself or his apparatus. The next day a lure (a dead marmot) was employed to attract the young fox within camera range. The marmot was placed at the foot of a short rock slide in the open woods and the camera set up a short distance away. The tame pup responded readily to the lure and it soon became necessary to stake it down to keep it from being dragged away. A number of interested persons photographed the animal over a period of several days, and the episode culminated in the fox becoming so absurdly indifferent to the presence of humans that it would approach to within several feet of the photographer, and it had to be driven away, almost forcibly, when bulbs and film were being changed to keep it from tearing up the bait animal and making off with it.

The young fox appeared to be about half adult size. After the first night only one of its den mates was seen, and this one did not seem to have the courage to approach the cameramen, although had it done so in the absence of the other the difference would probably not have been noticed. One of the young was observed several times when it was not in the vicinity of the bait and was not aware of the observer. On one of these occasions it was taking a sun bath and on another it was beside a large log playing with something it had captured, possibly a toad or mouse. In this play it acted much like a kitten, batting at the object with its paws and jumping into the air and landing on it with all four feet at once.

There were few people in this area and inquiry among the several local residents made it plain that the animal in question was not an escaped pet.—JAMES S. FINDLEY, *2645 Fairmount Blvd., Cleveland 6, Ohio. Received July 1, 1950.*

UNUSUAL BEHAVIOR OF THE NORWAY RAT

On June 29, 1950, the Superintendent of Maintenance at the Philadelphia Zoo called my attention to some young trees in which the upper branches had been stripped of large areas of bark. The damage was severe and he expressed concern that the trees might be killed outright by the animals attacking them. The species involved were weeping willow (*Salix babylonica*), catalpa (*Catalpa bignonioides*), and flowering crab (*Malus* sp.). They are located along an artificial "creek" which flows through a series of waterfowl enclosures. The damaged areas were mostly on the upper surfaces of horizontal branches ranging from four to twelve feet above the ground. The bark appeared to have been pulled from the branches in long strips rather than chewed off as a beaver does it.

The Philadelphia Zoological Garden, like many other zoos, has much trouble with rats and the above-mentioned waterfowl enclosures were heavily infested. I suspected that rats might be responsible for the damage and that they were gathering the bark for nesting material. Rat scats were thickly scattered over the ground under the trees. Schuyler rat traps baited with pork rind were wired about six feet above the ground in two willows and one crab tree. On July 6, 1950, I found a half-grown female Norway rat (*Rattus norvegicus*)

trapped in the crab tree. It was not pregnant, and the stomach contained Zoo bird food—not bark. On July 11 I trapped an adult female Norway rat in a willow tree. It weighed 310 grams and contained no embryos. There was no indication of recent lactation. The stomach held no bark, only zoo food. A large male rat was caught in the same willow tree on July 18. Its stomach contents were not examined.

Hamilton (American Mammals, p. 334, 1939) tells of Norway rats climbing a cherry tree to get the fruit, but such arboreal tendencies are more typical of the black rat (*Rattus rattus*). The only fruit on the Philadelphia Zoo trees was small, unripe crab apples which had not been touched. I do not believe that the baits lured the rats up the trees for it was a week before any trap was touched. Although the evidence is entirely circumstantial, I feel certain that the "barking" was done by Norway rats. However, my supposition that the bark was gathered for nesting material is not supported by the three specimens collected.—Frederick A. Ulmer, Jr., *Zoological Society of Philadelphia, Philadelphia, Pennsylvania.* *Received July 21, 1950.*

A NOTE ON THE BEHAVIOR OF THE CHIMPANZEE

Among my most interesting experiences with chimps in their native habitat was the observation made in Liberia, West Africa, in the dry season of early 1948. I was following a troop of approximately fifteen chimps moving hurriedly through dense second growth towards one of their favorite feeding grounds, an abandoned and thickly overgrown native rice patch. To keep up with the chimps it was necessary for me and my native guide to crawl on hands and knees for several hundred yards before we finally caught up with the troop.

I had seen many instances where heaps of broken and whole oil palm nuts lay scattered about bare surfaced rocks and had been assured by the native that chimps had been eating the nuts. When I drew near the troop they were actively engaged feeding, and among other sounds I heard a distinct pounding, at first in front of me, not one hundred feet away, and then from several other directions. My native guide quickly looked at me with a sly grin and remarked, "Cracking nuts." It seemed incredible, but there was no mistaking the hammering of rock against rock. I started immediately towards the nearest sound, squirming along on my stomach, fearful of making the slightest unnatural sound, and hoping that the wind would be favorable.

At last, I arrived at the edge of the dark, matted vegetation and glanced along the path before me. It was deserted, but I noticed a shell heap twenty-five feet away. I took no chances of being discovered as I quickly pushed up a barrier of dried leaves in front of me and waited. A moment later an adult male chimp came ambling around a bend, bearing an armful of dried palm nuts, supporting himself on his right knuckles. He reached the rock, sat down clumsily and proceeded to select a nut. He then picked up a chunk of rock and pounded the nut which had been placed on the flat surfaced rock. I watched this procedure for several minutes until an alarm note from the rear sent the troop scurrying off.—Harry Beatty, *Memorial Hospital, New York, N. Y.* *Received July 23, 1950.*

HABITAT PREFERENCES OF FOUR SPECIES OF *MICROTUS* IN JACKSON HOLE, WYOMING

During the course of field work at the Jackson Hole Wildlife Park laboratory at Moran, Teton County, Wyoming, in the summers of 1948 and 1949, the writer made observations upon the preferred habitats of four species of *Microtus* which occur in this region, and it is thought that these might be worth recording. The four species in question are: *Microtus pennsylvanicus modestus* (Baird), *Microtus montanus nanus* (Merriam), *Microtus longicaudus mordax* (Merriam), and *Microtus richardsoni macropus* (Merriam).

The habitats studied in which *Microtus* occurred were as follows: (1) sage-grass prairie on well-drained, gravelly, glacial till which covers wide areas in the floor of Jackson Hole; (2) willow-grass-sedge savannah which figures prominently in the hydrosere of the region and which, during rainy seasons, is often inundated; (3) wet grass-sedge meadows, also partially inundated during rainy weather; (4) a cultivated timothy meadow, well drained

and dry; (5) a lush grass-forb meadow, usually adjoining forest and well drained; (6) aspen consocies with a ground cover of grass and forbs, well drained and usually on slopes; (7) streamside alder-willow swamps; (8) forested, boulder strewn hillside, the haunt of *Neotoma cinerea* (The foregoing eight habitats lay at altitudes just below and above 7000 feet near the town of Moran.); (9) streamsides through open, shortgrass, subalpine meadows above 9000 feet in the Englemann spruce-alpine fir-whitebark pine zone; (10) alpine meadows above 10,500 feet, located on the high plateaus of the southern fringe of the Absoraka Range north of Togwotee Pass in Fremont County, Wyoming. The presence of the four species in these ten habitats is indicated by crosses in Table 1. A glance at these data readily shows that *montanus* is, in this region, the most widespread *Microtus*.

During 1948 the writer, working with Norman Negus of Oxford, Ohio, operated a number of half-acre quadrats in some of these habitats. These trapping units were patterned after those recommended by Bole (Sci. Publ. Cleveland Mus. Nat. Hist., 5:15–77, 1939) and were run for three night periods. No fixed number of traps was used, but the number was usually about 100 or 120 and these were placed in the most suitable trapsites within the quadrat. The total yields were used to obtain relative population figures. An indication of the relative abundance of three of these voles is given in Table 1 where the total three

TABLE 1.—*Presence of Microtus (X) in each habitat, and average number (in parentheses) of animals caught*

	SAGE-GRASS	WILLOW-GRASS-SEDGE SAVANNAH	GRASS-SEDGE MEADOW	TIMOTHY MEADOW	GRASS-FORB MEADOW	ASPEN CONSOCIES	ALDER-WILLOW SWAMP	FORESTED ROCKY HILLSIDE	SUB-ALPINE MEADOW	ALPINE MEADOW
No. quadrats averaged	4	2	1	1	1	2				3
pennsylvanicus		X (6.5)	X (4)	X (2)						
montanus	X (.5)	X (.5)	X (1)	X (14)	X (6)	X (3.5)	X			X (15.7)
longicaudus						X	X	X		
richardsoni									X	X (4.7)

night yields for the quadrats in several habitats are compared (figures in parentheses). From this it may be seen that *montanus*, in addition to being the most widespread, is generally the most numerous species. However, in two of the three habitats where *pennsylvanicus* was encountered it outnumbered *montanus*. The preferred habitat of *pennsylvanicus* is apparently the lush hydrosere communities which *montanus* inhabits only sparingly. *M. richardsoni* is typically an inhabitant of streamsides in subalpine meadows, but it often follows these streams down to somewhat lower elevations. It is absent from the floor of Jackson Hole even where apparently suitable habitat occurs. The taking of large numbers in the relatively dry alpine meadows (eight in one quadrat) was somewhat surprising. These quadrats were not in the vicinity of running or standing water. *M. longicaudus* was so scarce in 1948–49 that only five were taken despite intensive trapping, and they did not figure in quadrat records. This was of interest to the writer who, in 1947 at Gothic, Gunnison County, Colorado, had found this species rather common from timberline through the spruce-fir forest, in dry *Festuca* meadows, in aspen stands, and in willow-alder hydrosere communities. At this station *longicaudus* was the most ubiquitous vole.

Several generalizations may be drawn from these data pertaining to the Jackson Hole region:

1. *Microtus montanus nanus* is the most numerous and adaptable species of the four under discussion and apparently is somewhat less tolerant of extremely dry or wet habitats (i.e., sage and willow-grass-sedge savannah).

2. *Microtus pennsylvanicus modestus* is fairly common, but only in moist hydrosere communities to which it appears largely restricted.

3. *Microtus richardsoni macropus* is most numerous along small, open streams in the shortgrass subalpine meadows of the Absoraka Range.

4. *Microtus longicaudus mordax*, while rare in 1948–49, occurs in a fairly wide habitat range.

The work herein reported upon was made possible through a grant-in-aid from the Jackson Hole Wildlife Park, Moran, Wyoming.—James S. Findley, *2645 Fairmount Blvd., Cleveland Heights, Ohio.* *Received June 5, 1950.*

NEW RECORDS OF MAMMALS FROM JALISCO, MEXICO, FROM BARN OWL PELLETS

Ninety-one owl pellets, taken on January 29, 1949, 21 miles southwest of Guadalajara, Jalisco, by J. R. Alcorn, were received recently by the University of Kansas Museum of Natural History. On the same date a male barn owl (*Tyto alba pratincola*), UKMNH no. 28267, which presumably accounted for these pellets, was obtained from a roost directly above the place from where the pellets were gathered. The region surrounding the roost consists of relatively open grasslands which have been excessively over grazed. Alcorn reports that the herbaceous cover is so scant that small mammals are exceedingly low in numbers and that intensive trapping with mouse traps produced only small catches.

Table 1.—*Vertebrates found in barn owl pellets, Jalisco, Mexico*

Species	Occurrence in pellets	Total no. of individuals	Per cent of occurrence
Cryptotis pergracilis	18	17	6.8
Notiosorex crawfordi	2	3	1.2
Citellus mexicanus	1	1	.4
Liomys irroratus	25	28	11.2
Perognathus flavus	36	38	15.2
Reithrodontomys fulvescens	1	1	.4
Baiomys taylori	36	40	16.0
Peromyscus maniculatus	56	80	32.0
Oryzomys couesi	2	2	.8
Sigmodon hispidus	19	17	6.8
Neotoma ferruginea	1	1	.4
Unidentified birds	24	22	8.8
Totals		250	100.0

Identification of the mammals was made by examination of crania and lower jaws which were taken from the pellets. The availability of a collection of mammals from the immediate vicinity of the owl roost was of great assistance in identifying the mammals to species and subspecies. The number of occurrences of mammals in the pellets was based upon the number of crania and lower jaws present.

Remains representing 250 vertebrates (228 mammals and 22 birds) were found in the 91 owl pellets, indicating an average occurrence of approximately 2.7 individuals per pellet. No invertebrates were found. The remains of 228 mammals were found to belong to 11 genera in the following families: Soricidae, 20 (8.8 per cent); Sciuridae, 1 (0.4 per cent); Heteromyidae, 66 (29.0 per cent); Cricetidae, 141 (61.8 per cent).

As shown in Table 1, *Peromyscus maniculatus* was the most numerous mammal found;

remains of this species included 32.0 per cent of the total number of vertebrates. *Baiomys taylori*, *Perognathus flavus*, and *Liomys irroratus* were next in abundance in the order named.

Of special importance was the finding of three skulls of *Notiosorex* in the pellets. In comparison with published descriptions, these skulls are referred to the species *N. crawfordi*. Previous to this, the most southern record for this species was Mazatlan, Sinaloa (see Fisher, Jour. Mamm., 22: 265–266, 1941). *Notiosorex crawfordi evotis* (Coues) was named from Mazatlan and is known only from that locality. Alcorn took one adult male *N. crawfordi* (UKMNH no. 33318) near the owl roost at 13 miles south and 15 miles west of Guadalajara on May 28, 1949.

The finding of a large number of individuals of *Perognathus flavus* in the owl pellets is noteworthy. This find extends the range of this species west and south in Jalisco. Alcorn obtained only a small series by trapping in this general area. These are referred to *P. flavus mexicanus*.—John W. Twente and Rollin H. Baker, *Museum of Natural History, University of Kansas, Lawrence, Kansas. Received June 2, 1950.*

NOTES ON THE RICE RAT IN NEW JERSEY AND PENNSYLVANIA

Comparatively little information has been added to our knowledge of the rice rat (*Oryzomys palustris*) in New Jersey and Pennsylvania since Samuel N. Rhoads published his "Mammals of Pennsylvania and New Jersey" in 1903. At that time he limited it to "the tidewater lands of Delaware Bay" and listed three stations where the rodent had been collected in New Jersey: (1) Dr. Richard Harlan's vague type locality of "'Fast Land' in the vicinity of Salem," Salem County; (2) the salt marshes of Cedar Creek near Cedarville, Cumberland County, where the rice rat was rediscovered in 1898 by Henry W. Warrington; and (3) the brackish marshes of Cohansey Creek near Greenwich, Cumberland County, where Rhoads collected them. He listed Bayside and Newtown (Newport), Cumberland County, from hearsay reports of muskrat trappers, but no specimens were secured from those places.

To the above list I wish to add two localities that considerably extend the known range of *Oryzomys* in southern New Jersey. A barn owl pellet collected for me by Mrs. William Lukens in the salt marshes at Fortescue, Cumberland County, on March 26, 1949, contained the skull of a young adult rice rat. It also contained the skulls and bones of three meadow voles (*Microtus p. pennsylvanicus*). On September 22, 1946, two members of the Delaware Valley Ornithological Club, Edward Manners and Richard F. Miller, found a small rat dead on a railroad embankment in the salt marshes at Cape May, Cape May County, New Jersey. They realized that it was something unusual and brought it to me for identification. It proved to be an immature female rice rat. Since I am aware that *Oryzomys* is frequently confused with the young Norway rat, I carefully checked the tooth pattern and plantar tubercles as well as the general external appearance. This locality, just back of the town of Cape May, near Cape Island Creek, carries the range of the rice rat to the ocean side of the state. It may occur even farther north in the ocean marshes which extend to the head of Barnegat Bay 90 miles to the north, despite the fact that Rhoads failed to get it at Tuckahoe or Tuckerton. Dr. Witmer Stone, an excellent mammalogist, missed it completely during his many years of summer residence at Cape May. In my experience it is not an easy animal to trap.

Rhoads stated in 1903 that *Oryzomys* did not occur in Pennsylvania. Since then Gilmore has recorded it from Indian sites at Martin, Fayette County, and Fort Hill, Somerset County, in southwestern Pennsylvania (Jour. Mamm., 27: 227–234, 1946). These specimens are not thought to be more than 500 years old. Despite Gilmore's statement that the rice rat occurs in brackish-water swamps of eastern Pennsylvania, I am aware of no records backed by specimens. Since it is found in the Delaware River marshes of the state of Delaware (Schantz, Jour. Mamm., 24: 103–104, 1943; Ulmer, Jour. Mamm., 25: 411, 1944), the most logical place to look for it in eastern Pennsylvania would be the Tinicum Marshes of Delaware and Philadelphia counties. During the past fifteen years I have tried to obtain evidence of its presence there by means of trapping and the examination of the pellets of

barn owls and short-eared owls, but without success. This, of course, does not mean that it did not occur there previously. The character of those marshes has been vastly changed in recent years by human activities, especially draining, dredging, and pollution.

In view of this, I believe that the following excellent field observations by Richard F. Miller, of the Delaware Valley Ornithological Club, are worth recording. "June 11, 1916. Tinicum, Delaware County, Pa. Startled five apparently full-grown marsh rats from a grebe-like nest (a deserted Virginia rail's nest, enlarged and roofed over) when I reached down and opened it, expecting to find a set of pied-billed grebe's eggs in it! They scrambled quickly out and disappeared into the water before I, amazed at finding rats in the nest, ever thought of trying to capture one. The nest was built upon water twelve inches deep, in the edge of a patch of cattails five feet high, along a ditch in a meadow full of tussocks and rushes (*Scirpus*), near Darby Creek dike and not far from Long Hook Creek. The nest, composed entirely of tule (*Typha*) blades with the finer ones inside, was eight inches wide and four inches deep inside. It was almost globular in shape and at least twelve inches in diameter. I do not know where the entrance was, probably in the side. It was within several feet of a least bittern's nest containing four eggs." Mr. Miller has also told me that, "In 1917, during World War I, the Tinicum Marshes were drained to control mosquitoes, but they reverted back again to marshes in several years through neglect to keep the sluices open."—FREDERICK A. ULMER, JR., *Academy of Natural Sciences of Philadelphia, Philadelphia, Pa.* *Received July 28, 1950.*

THE MEADOW JUMPING MOUSE IN SOUTHERN ILLINOIS

Records of the meadow jumping mouse (*Zapus hudsonius*) in Southern Illinois are rare. Necker and Hatfield (Chicago Acad. Sci., 6: 56, 1941) list only one occurrence for the region known as little Egypt or the Southern third of the state. This specimen which is in the Museum of Natural and Social Sciences of Southern Illinois University is from Jackson County and was collected July 5, 1940.

The authors have the following records to add to the previously existing one: One young male was taken in the fence rows on the Southern Illinois University farm May 30, 1943. Two additional adult males were taken by trapping from along fence rows in typical farm land in Perry County, near Pyatt, Illinois, April 26, 1948.

Several unauthenticated records seem to indicate that this species is more abundant in Southern Illinois than has been generally believed. Study skins of these three specimens are in the collections of the authors.—WILLARD M. GERSBACHER AND JULIUS R. SWAYNE, *Department of Zoology, Southern Illinois University, Carbondale, Illinois.* *Received June 26, 1950.*

A TECHNIQUE FOR CONTINUOUS RECORDING OF SUBCUTANEOUS TEMPERATURES OF WILD MICE

It is often advantageous to secure continuous recordings of body temperatures of mice and other small mammals in connection with physiological experiments. The advantage of a continuous series of recordings is that true standard or basal temperatures may be obtained, as well as the entire range of temperatures under varying conditions of activity. The usual methods of taking body temperatures involve handling of the animal, causing rises in body temperature due to excitement and struggling. Such temperature changes may be considerable (Britton and Kline, Amer. Jour. Physiol., 125: 730–734, 1939; Kendeigh. Jour. Mamm., 26: 86–87, 1945).

Different workers have attempted to obtain continuous recordings of body temperature of small mammals with varying degrees of success (Burbank and Young, Jour. Physiol., 82: 459–467, 1934; Crozier, Pincus and Renshaw, Jour. Gen. Physiol., 18: 491–497, 1935). A recent method (Vernet and Metcalf, Science, 107: 655–656, 1948) in which a thread thermocouple was passed through the subcutaneous tissue around the anterior thoracic region was found to be successful in obtaining continuous records of subcutaneous temperatures in laboratory mice.

None of the previously described methods has been found applicable to wild mice. Since wild mice are not as docile as laboratory mice, any permanently attached device which is at all cumbersome or which is placed on some part of the body which can be reached by the mouth or legs will quickly be chewed or scratched out.

In experiments designed to obtain a continuous series of subcutaneous temperatures of wild white-footed mice (*Peromyscus leucopus noveboracensis*), the following method was found to be satisfactory. Small copper and constantan silk-insulated wires of about six inches in length were coated thinly with collodion and were then twisted together for a distance of about two and one-half inches and were again coated with collodion except at the thermocouple junction. The mouse was anaesthetized, and a very tiny incision made in the dorsal neck region just posterior to the ears. The thermocouple was then inserted beneath the skin of the back and secured in place by a single suture. A small round fiber disc was passed over the thermocouple wires and fastened to the fur over the incision by means of collodion. Small cylindrical glass beads were threaded above the fiber disc for a distance of one-half inch and coated over with collodion to provide additional protection from scratching by the animal. With the thermocouple in this position the animal could not remove it with either fore or hind feet and was unable to reach it with its teeth. Upon completion of the operation, the whole attachment projects somewhat like a miniature antenna from the

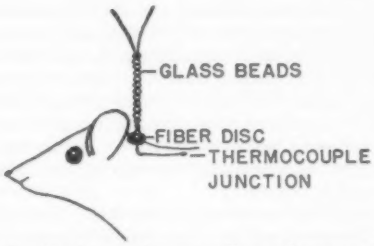

FIG. 1.—Thermocouple attachment for recording subcutaneous temperatures of wild mice.

head of the animal and is tolerated with a minimum of discomfort (Fig. 1). The free leads of the thermocouple may then be connected with a self-recording potentiometer for continuous recording or with a portable indicator potentiometer for individual readings.—JOHN A. SEALANDER. *Department of Zoology, University of Arkansas, Fayetteville. Received July 22, 1950.*

FIELD METHODS FOR COLLECTING MAMMAL ECTOPARASITES

The methods described here were developed to meet the requirements of field workers who have the opportunity or the need to save specimens of ectoparasites, but must do so with a minimum of time and special equipment. These techniques were developed in cooperation with Dr. George E. Wallace, Associate Curator of Insects and Spiders at Carnegie Museum, and were used in the field by the writer and other members of the Survey of Pennsylvania Mammals, since 1946. (Pittman-Robertson Project 20-R, Federal Aid in Wildlife Restoration)

Most of the smaller mammals were taken in ordinary snapback traps, and as they were removed from the traps, they were placed in separate paper bags. For the small mammals ordinary waxed sandwich bags were used, and for the larger animals waxed garbage bags proved satisfactory. Both of these are easily obtained. Approximately one teaspoonful of paradichlorobenzene crystals was put in the bag with the mammal. In about twenty minutes the mammal was removed, leaving ticks and fleas in the paper bag. The bag was then given a catalogue number and sent to the Section of Insects and Spiders, Carnegie Museum,

Pittsburgh, Pennsylvania, where the parasites were removed and transferred to alcohol for preservation and study.

It has been our experience that this procedure permits the recovery of most of the fleas and ticks, and some of the lice, but very few mites. When it was desired to obtain a higher recovery of lice and mites, the mammal, after it was removed from the paper bag, was brushed over a piece of plain paper and the brushings placed in a vial of 80 per cent alcohol. This vial was then given the same number as the paper bag so that both lots were identified as coming from the same host. These brushings have yielded small lice, mites, and the early stages of ticks that would not otherwise be collected in the field without special equipment. We found that lice and seed ticks could be brushed out of the fur of larger animals (rabbits and larger) if, after the animal was skinned, paradichlorobenzene was dusted into the fur and the pelt rolled up for approximately twenty minutes.

We observed that many fleas will remain in the fur after the mammal has become cold. This is especially true when the air temperature is much lower than normal body temperature, or when the outer fur is wet. At such times the fleas do not start to leave the fur until the host is moved.

In the fur sheds we visited, we noticed that whenever a cold animal was brought into a warm room, seed ticks and fur mites migrated out to the tips of the hairs. We took advantage of this by thoroughly brushing such animals over a newspaper. The resulting collection of fine debris and parasites was then emptied into a sandwich bag and the bag labelled. Later, the contents of the bags were transferred to vials of alcohol and properly labelled. Where the parasite had caused damage to all or part of the pelt, this was noted.

To collect mange mites (Sarcoptidae) from dry pelts or dead animals the following method proved to be most satisfactory for field work since it too required a minimum of equipment and permitted recovery of mites from either dried pelts or fresh specimens. Mangy portions of the pelt were removed and pinned out to dry. When they were thoroughly dry, they were stored in waxed paper sandwich bags together with the necessary data.

To obtain the mites from these specimens, or from fresh material, small strips or pieces one to two inches long were cut from the sample, placed in a quart jar or wide mouthed bottle of water to which one tablespoonful of Dreft had been added. These pieces were soaked until the skin was soft. (Other detergents should work as well or better, but Dreft was found to be the most satisfactory of those that are generally available.) Sometimes soaking was necessary for several hours or over night in the case of thick, hard specimens. After the skin was softened, the infected areas were scraped and shaken thoroughly to remove all loose material. The pieces of skin were removed and the suspended material in the water permitted to settle. The dirty water was decanted off and clean water added. The first settling takes longer as the water is usually quite dirty and the mites settle slowly, but in the second or third washings, the mites and fine particles of dirt settle out more rapidly.

If it is desired, the sediment can be examined immediately with a microscope, and the mites removed, or the sediment can be preserved in alcohol or formalin, and the mites removed later.

By using this method, large numbers of *Sarcoptes scabiei* have been recovered from fox pelts (*Vulpes*) that were a year old at the time they were examined.

Another method especially suited to removing mange mites from skin samples is described by Hopkins (Proc. Zool. Soc. London, 119, pt. 2: 387–604, 1949). This method consists of placing the skin sample in a 5 per cent solution of sodium hydroxide until the hair and skin dissolve; then the mites may be obtained by filtering, or by washing and decanting. The author recommends this procedure where it is not necessary to preserve the skin. Although we have used it to collect mange mites, it should be especially useful in collecting bird lice and mites which are often difficult to remove from feathers.

Fly larvae from warbles (*Cuterebra*) were preserved by dropping them into 80 per cent alcohol or 10 per cent formalin. When time and facilities permit, it is better to drop the larvae into water that is almost boiling, and then let the water cool before transferring the

larvae to alcohol or formalin. When killed in hot water, the larvae die extended, thus facilitating the examination of the structures necessary to identify them.

The label with each lot of parasites should include the name of the host, the locality where it was found, the date collected, and the name of the collector. Any additional observations about the parasite or its effect on the host should be included.

For special studies, when it is desired to handle ectoparasites alive, either for shipment or to rear them, the following papers will be found useful: James, Maurice T., The flies that cause myiasis in man. Miscl. Publ. 631, U.S. Dpt. of Agric., Sept., 1947, Washington, D.C. (This paper has a section "Technique for rearing, preserving, and shipping flies and fly larvae," pp. 25–30) and Farrell, Charles E., and G. W. Wharton. A successful method of shipping larval trombiculids (chiggers). Jour. Parasit., 34, (1), Feb. 1948.—Neil D. Richmond, *Pennsylvania Game Commission, Harrisburg, Pa.* *Received February 24, 1950.*

A PRACTICAL METHOD FOR MOUNTING THE BACULA OF SMALL MAMMALS

Several papers have appeared in the past few years pointing out that the baculum is a useful anatomical structure for clarifying the relationships of groups of mammals whose taxonomic affinities are questionable. Stimulated by these works, a number of individuals established collections of bacula. Most of these bacula were obtained from animals preserved in alcohol or from dried study skins on which the sheaths of the bacula had been everted and allowed to remain. The minute size of the baculum of a small mammal almost necessitated mounting it on a glass slide or placing it in a vial; consequently these collections, for the most part, have been kept separate from collections of skins and skulls. Upon the suggestion of Professor E. Raymond Hall, I developed a means of conveniently housing the baculum in the same vial that contained the skull.

Many specimens were obtained by me from dried study skins on which the collectors had made no conscious attempt to preserve the bacula. From study skins of male *Eutamias* and *Reithrodontomys* a small area of skin was cut from around the venter and bacula were recovered from 40 per cent of them. As many as 20 samples were processed at a time. This was done by drilling 80 holes in a board, 2 inches thick, 12 inches wide and 24 inches long. The holes were arranged in rows of 20 each and a vial was placed in each hole. The vials of each row contained a portion of one of the four solutions which were used. The samples were processed by using a modification of a method for staining skeletons of cleared embryos, as developed by Dawson (Stain Technology, 1:123–124, 1926) and Lipman (Stain Technology, 10:61–63, 1935), as follows: Each sample was placed into four successive solutions and allowed to remain overnight in each solution. The solutions, in order of usage, were: (1) distilled water; (2) one part of alizarin red S to 10,000 parts of 2 per cent KOH; (3) 80 per cent glycerin and (4) 100 per cent glycerin. The bacula were dissected out upon removal from the alizarin solution (the second solution in order of usage).

Plexiglass, $\frac{1}{16}$ inch thick, was cut into squares $\frac{1}{2}$ inch on a side. Rings of sheet plastic (cellulose acetate), $\frac{1}{32}$ inch thick, $\frac{3}{4}$ inch in outside diameter, and $\frac{1}{2}$ inch in inside diameter, were cut. Standard coverglasses, $\frac{1}{2}$ inch on a side, were obtained. The museum catalogue number was scratched with a sharp-pointed instrument on the plastic rings and the graphite of a lead pencil was rubbed in these scratches. A plastic ring was secured to the square of plexiglass with balsam. The baculum was then placed in the thus formed depression and covered with balsam and a coverglass. Since the smaller of the two sizes of glass vials usually used in museums to house skulls of mammals has an inside diameter of $\frac{3}{4}$ inch, the mounted baculum conveniently fits in a skull vial.—John A. White, *Museum of Natural History, University of Kansas, Lawrence, Kansas.* *Received August 28, 1950.*

THE TECHNICAL NAMES OF THE FALLOW DEER AND THE VIRGINIA DEER

With reference to a note on this subject by Hershkovitz (Jour. Mamm. 30: 94, 1949), I owe him an apology for having misled him. The International Commission on Zoological Nomenclature, in Paris, in July 1948, did not validate *Dama* for the fallow deer. What they did was:

(a) to declare *Dama virginiana* Zimmermann, 1780, available for the Virginia deer.

(b) to take note of the representations received as to the confusion to be expected if the generic name *Dama* were now to be transferred from the European fallow deer to the American Virginia deer.

(c) to invite the Secretary to the Commission, by means of notice in the *Bulletin of Zoological Nomenclature* and otherwise, to obtain as rapidly as possible the views of interested specialists on the question whether they would like the Commission to use their plenary powers to prevent the transfer mentioned in (b).

(d) to recommend specialists to refrain from transferring the generic name *Dama* from the fallow deer of Europe to the Virginia deer of America, pending the outcome of (c). (Bull. Zool. Nomencl. 1950, 4: 551, refers).

Seeing that it rests with us whether an irritating and confusing transfer is to take place, or whether we continue to use the names *Dama* and *Odocoileus* in their well-established meanings, I have sent the following request to the Secretary of the International Commission on Zoological Nomenclature, 28 Park Village East, Regent's Park, London, N.W. 1, England, and ask colleagues to write a line in support. I gather that all that is necessary is to refer to this notice and express concurrence:

IT IS REQUESTED THAT THE INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE SHALL —

(1) use its plenary powers:—
  (a) to validate the generic name *Dama* Frisch, 1775 (*Natur-syst. vierf. Thiere:* 3);
  (b) to designate *Cervus dama* Linnaeus, 1758 (*Syst. Nat.* (ed. 10) 1: 67), as the type species of the foregoing genus;
(2) place the under-mentioned generic names on the *Official List of Generic Names in Zoology:*—
  (a) *Dama* Frisch, 1775, as validated under (1) (a) above (type species, by designation under the plenary powers under (1) (b) above: *Cervus dama* Linnaeus, 1758) (gender of generic name: feminine);
  (b) *Odocoileus* Rafinesque, 1832 (*Atlantic J.* 1(3): 109) (type species, by monotypy: *Odocoileus speleus* Rafinesque, 1832, *Atlantic J.* 1(3): 109) (gender of generic name: masculine);
(3) place the under-mentioned trivial names on the *Official List of Specific Trivial Names in Zoology:*—
  (a) *dama* Linnaeus, 1758 (as published in the binominal combination *Cervus dama*);
  (b) *virginiana* Zimmermann, 1780 (*Geograph. Gesch.* 2: 129) (as published in the binominal combination *Dama virginiana*);
  (c) *speleus* Rafinesque, 1832 (*Atlantic J.* 1(3): 109) (as published in the binominal combination *Odocoileus speleus*).

T. C. S. MORRISON-SCOTT, *British Museum (Natural History), Cromwell Road, London: S.W.7.* *Received October 23, 1950.*

THE NOMENCLATURE OF *CANIS ANTARCTICUS*

Recently Iredale (Proc. Roy. Zool. Soc. New South Wales, Sept., pp. 35-36, 1947) has shown the earliest name of the dingo to be *Canis antarcticus* Kerr, 1792, replacing the well-known *Canis dingo* Meyer, 1793. This is a doubly unfortunate situation, since Kerr's *C. antarticus* (sic) causes *Canis antarcticus* Shaw, 1832, the commonly used name for the Falkland Island wolf, to fall as a homonym. This is a case where a fiat ruling by the International Commission on Zoological Nomenclature would be beneficial.—G. H. H. Tate, *American Museum of Natural History.* *Received August 23, 1950.*

A SUBSTITUTE NAME FOR *TAXIDEA TAXUS NEVADENSIS* SCHANTZ

I am indebted to Dr. E. Raymond Hall for bringing to my attention the fact that *Taxidea taxus nevadensis* Schantz (Jour. Mamm., 30: 304, August 20, 1949) was preoccupied by

a fossil badger originally named *Taxidea nevadensis* Butterworth (Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, pp. 21–24, October 3, 1916), from Thousand Creek Pliocene, northern Nevada.

I shall name the recent badger from the White Sage Flat, Desert Game Range, Nevada, **Taxidea taxus halli** for E. Raymond Hall, who made a monumental contribution to mammalogy by publishing "Mammals of Nevada."—VIOLA S. SCHANTZ, *Fish and Wildlife Service, U. S. Department of the Interior, Washington, D. C.* *Received November 17, 1950.*

REVIEWS

O'Neil, Ted. THE MUSKRAT IN THE LOUISIANA COASTAL MARSHES; A STUDY OF THE ECOLOGICAL, GEOLOGICAL, BIOLOGICAL, TIDAL, AND CLIMATIC FACTORS GOVERNING THE PRODUCTION AND MANAGEMENT OF THE MUSKRAT INDUSTRY IN LOUISIANA. New Orleans: Louisiana Department of Wild Life and Fisheries, Pp. xii + 152, 61 figs., 1949. Price $3.00.

This book was written in semi-popular style in order that it might be useful to marsh operators and biologists, alike. Its scope is indicated by the subtitle and, in keeping with the defined objectives of a five-year (1940–45) Federal Aid Project, includes little indeed that does not have an obvious bearing on the practical management of a fur resource in the Gulf Coast region.

The outstanding contribution of the study is—and was meant to be—its discussion of the origin and successions of coastal marshes of southern Louisiana and of the tremendous importance of "three-cornered grass," *Scirpus olneyi*, in the ecology of the Louisiana muskrat, *Ondatra zibethica rivalicia*. This plant not only is instrumental in building up some of the highest muskrat densities to be found on earth but also tends, in turn, to be ruinously exploited by the overpopulations built up. From the author's introduction:

"Prior to and during the early stages of this study it was the general consensus of laymen and even that of many trained biologists that the annual catch of six to ten million muskrats was rapidly depleting the fur resources of the State. . . .As a result of this study, however, it is now known that the general muskrat picture on the Gulf Coast is one of overpopulation and its resulting damaging effects, rather than the previously assumed under-population. The muskrat's reproductive capacity and ability to evade traps is still far ahead of man's under-estimated opinion of him. Not until the marshes are more rigidly supervised by men who have learned from actual experience will the crop be sufficiently harvested to the point of preventing overpopulation."

A reader attempting to compare the life history and ecology of the Louisiana muskrat with that of northern subspecies will find the book highly informative in many ways, though hardly at all, or not at all, in many others. It does appear that *rivalicia* may differ rather surprisingly from most of the other subspecies of muskrats (particularly from *zibethica*, or what southerners call the northern muskrat) in behavior and physiology; the apparent greater psychological tolerance of *rivalicia* to crowding in choice environment, the drowning of *rivalicia* under ice, the stated inability of young *rivalicia* to take care of themselves when swimming about lodges in deep water marshes, the breeding of the subspecies at very early ages, in these and other respects are certain of the differences exemplified.

The conclusion that the muskrat populations of the Gulf Coast marshes are a quite recent phenomenon may startle people who are familiar with the long histories of famous muskrat marshes elsewhere, and one may wonder just where well-differentiated *rivalicia* lived a century ago, when seemingly nobody knew of muskrats in the habitat that now teems with them.

As management measures, in addition to closer trapping of populations showing signs of becoming overabundant, Mr. O'Neil recommends controlled burning of marshy growths in fall and winter to promote the *Scirpus olneyi* subclimax, supplemented by engineering manipulation of ditches, dams, etc., as required. He quotes an unnamed trapper who "once summed up the entire problem of management in a few words, 'Produce a good

three-cornered grass marsh, then fight like hell trying to keep the 'rats from eating it up'."—PAUL L. ERRINGTON.

Methuen's Monographs on Biological Subjects. General Editors: G. R. de Beer and Michael Abercrombie. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16. Price $1.25 each. Three of these monographs, now being published in the United States, should be of interest to mammalogists.

THE ECOLOGY OF ANIMALS by Charles Elton, 97 pp., is an informative account of ecology, written in a style that is understandable even by the undergraduate student. It is devoid of complicated phraseology and terminology so prevalent in modern ecological writings.

THE CLASSIFICATION OF ANIMALS by W. T. Calman, 54 pp., is a readable little book in which the importance of systematic zoology is ably and simply told. The reviewer recommends this book as outside reading for graduate students in Zoology. Also, many of the "Laboratory Zoologists" would probably be more sympathetic toward the taxonomist if they were to read its pages.

MENDELISM AND EVOLUTION by E. B. Ford, 122 pp., summarizes the fundamentals of Mendelian genetics and discusses its application to evolutionary problems in Nature.

The above three books, all small, but packed with good information, are handy references to have on the shelves, particularly for those who are engaged in graduate instruction in zoology at our universities and colleges. The modest price of $1.25 each, in these times, should encourage a wide distribution.—WILLIAM H. BURT.

RECENT LITERATURE

(Conducted by G. S. Miller, Jr., Emma Charters, D. H. Johnson, and R. H. Manville)

[Reprints of this section may be purchased from the Corresponding Secretary]

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ANONYMOUS. Just one of the family: a tame lioness, at home. Illus. London News, vol. 216, no. 5787, p. 427, illus. March 18, 1950.

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COMMENT AND NEWS

AMENDMENT TO BY-LAWS

At the 30th annual meeting, the Board of Directors recommended the following amendment to the By-laws:

Article VIII

Present wording.—Sec. 2. Any member upon payment of one hundred dollars at one time shall be entitled to life membership, and shall be exempt from membership dues.

Recommended alteration.—Sec. 2. Any member upon payment of one hundred dollars at one time, or in four payments of twenty-five dollars each in four consecutive years, shall be entitled to life membership, and shall be exempt from membership dues from the time of the initial payment.

This amendment will come up for vote at the next annual meeting.

SPELLING OF SCIENTIFIC NAMES

The recommendations (regarding spelling of scientific names based on surnames) of the International Commission on Zoological Nomenclature (Bull. Zool. Nomen., 4:205–209, May, 1950) are being followed in this and subsequent numbers of the Journal of Mammalogy. The one that affects most names used in mammalogy is: to the exact surname of the person concerned there be added the appropriate termination in the genitive case—to a trivial name based on the surname of a man, "i," to one based on the surname of a woman, "ae."

KURODA HONORED

In honor of Nagamichi Kuroda, leading Japanese mammalogist, The Ornithological Society of Japan has published a special commemorative number of its Bulletin "Tori" (vol. 12, no. 59, Dec., 1949). This number of Tori includes a list of publications by Kuroda.

GRANTS-IN-AID

The New York Zoological Society again announces grants-in-aid available for the research program at its Jackson Hole Research Station. The fifth summer program (1951) will include studies in ecology, animal behavior, and land management. Further information may be obtained by addressing Director, *Jackson Hole Research Station of the New York Zoological Society, Moran, Wyoming.*

DEATHS

Recent deaths reported are: **Kenneth Cook,** Douglas, Wyoming, 1950; **Albert Joseph Bernard Kirn,** Life Member, Somerset, Texas, October 1, 1950; **Dr. George Clark Rinker, Sr.,** Hamilton, Kansas, November 12, 1950; **Miss Annie M. Alexander,** Suisun, California, September 10, 1950; **Dr. Henry E. Ewing,** Takoma Park, Maryland, January 5, 1951; **Dr. Chester Stock,** Pasadena, California, December 8, 1950.

Journal of Mammalogy, Vol. 31, No. 4, was mailed **November 21, 1950**

NOTICE OF ANNUAL MEETING

The Thirty-first Annual Meeting of the American Society of Mammalogists will be held at the Chicago Natural History Museum in late June. Make plans to attend. A detailed account, with dates, will be in the May issue of this Journal.

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